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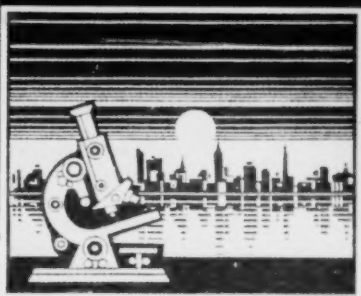
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ABSTRACT

This curriculum supplement was designed to correlate directly with "A Guide to Curriculum Planning in Technology Education," published by the Wisconsin Department of Public Instruction. It is also a companion book to three other classroom activity compilations, one in each of the other three major systems of technology--manufacturing, communications, and transportation. The entire set--the curriculum guide and the four activity books--follows the content organization given in the "Technology Education Content" fold-out chart in this guide. The activities are organized on the basis of how each supports one of the construction concepts identified on the chart. Materials for this supplement were gathered from throughout Wisconsin and several other states, and most of them were developed by teachers. The six sections of the guide include 14 activities grouped under the following topics: research and development, building the structure, installing utility systems, servicing the project, planning, and directing. Each activity consists of a description, resources needed, objectives, evaluation focus, procedures, information sheets illustrated with line drawings, and (sometimes) tests and answer sheets. (KC)

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Technology Education

CLASSROOM ACTIVITIES IN CONSTRUCTION

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Technology Education: Classroom Activities in Construction

Richard Kitzmann
Supervisor, Technology Education

John Benson
Administrator
Division for Instructional Services

Richard Dignan
Director
Bureau for Vocational Education

Eunice Bethke
Chief
Consultation Section

Wisconsin Department of Public Instruction
Herbert J. Grover, State Superintendent

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Wisconsin Department of Public Instruction
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P. O. Box 7841 ~
Madison, WI 53707-7841
(608) 266-2188

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Foreword

Technology education is particularly well-suited to respond to our "Education for Employment" initiative and to facilitate career exploration for our students. The classroom activities in this resource relate directly to the technology of construction, one of the four major systems identified in *A Guide to Curriculum Planning in Technology Education* as vital for helping students to understand the technological concepts and processes of the world around them. The other three systems are communications, manufacturing, and transportation, and the Department of Public Instruction has prepared a compilation of relevant activities in each of those systems as well.

As teachers use the concepts contained in the guide and in these companion activity books, we hope they will develop new teaching directions that will enhance students' understanding of technology education and its impact on their present and future lives and careers. We must ensure the timeliness of this particular curriculum because we live in a world affected in every aspect by a variety of sophisticated, often baffling, technologies. In construction, for example, we have sophisticated computer-guided machinery, and complex fabrication methods for building housing, factories, public buildings, bridges, and airports. It is possible to build bigger, stronger, and faster than in the past decades, and to use space-age materials and methods. These possibilities bring with them the potential for immense social change.

Technology education must take responsibility for imparting a basic understanding of the technological foundations of the many aspects of construction. Materials, products, processes, problems, uses, and developments in the field of construction must be an ongoing study, and timely occupational skills must be developed in our students.

These activities have been gathered to facilitate those ends. We encourage teachers, as they use these activities, to modify, expand, and reorganize them to fit individual classroom needs. These activities are intended to be subject to change and continuous improvement, so the Department of Public Instruction welcomes suggestions from users.

Herbert J. Grover
State Superintendent

Acknowledgments

It is not possible to list each teacher or agency that contributed to this collection of activities. Yet without the efforts of many in the field, this publication would not have been possible. We thank everyone that helped assemble this collection for graciously responding to our requests and for freely sharing their knowledge.

Special thanks are due to John Vanderhoof, former Department of Public Instruction (DPI) technology education consultant, for his part in gathering and clarifying the activities; to Dr. Leonard F. Sterry, program director for technology education majors, at the University of Wisconsin-Stout, who provided the original format and organized data collection from the field; and to Dr. Eunice Bethke, Chief, Consultation Section, DPI, for her facilitation and support.

Other DPI staff should also be acknowledged, especially Kathleen D. McCleave, editor of this supplement, for her efforts to find a consistent format and language for the activities and for her insistence on clarity and accuracy in the instructions. She was assisted with book design and graphics by Lisa Buckley. Additional thanks go to Barbara Sumwalt, technology education program assistant; Danni Jorenby, word processor/typesetter; and Kris Whitman, proofreader.

Introduction

This curriculum supplement, *Technology Education: Classroom Activities in Construction*, was designed to correlate directly with *A Guide to Curriculum Planning in Technology Education* published by the Wisconsin Department of Public Instruction (DPI). It is also a companion book to three other classroom activity compilations, one in each of the other three major systems of technology—communications, manufacturing, and transportation.

The entire set—the curriculum guide and the four activity books—follows the content organization given in the "Technology Education Content" fold-out chart. Thus, the activities in this particular book are organized on the basis of how each one supports one of the construction concepts identified on the chart. An activity listed as "2C," for example, would have to do with "Installing Utility Systems" within the "Production Processes" phase of construction; an activity listed as "3A" would relate to "Planning" as one of the "Managerial Processes" of construction.

Materials for this supplement and the companion documents were gathered from throughout Wisconsin and several other states. Most of the activities were originally developed by individual instructors who are actively teaching portions of the technology education curriculum. Some were developed by state departments of education and by projects supported by those agencies. Still other materials were developed at universities. Since this was a process of *collection*, not *creation*, of materials, some content concepts are not covered at all, and others are represented by several activities. Also, as a collection of activities, this supplement does not contain a master plan for utilization and does not represent full courses. Instructors must identify major themes to be taught in support of these activities, such as the research and development process, system components, safety and tool/machine use, input-process-output model, and so on. In this regard, the content chart can be a useful tool for the development of courses consistent with the philosophy of technology education.

Due to the process used to solicit and assemble these activities, there are additional points that should be kept in mind while using this material.

- The three-hole punched format was selected to permit the publication of the best activities available now, while making it easy to revise and update the activities later. Teachers are encouraged to share new activities as they are developed, or to suggest refinements of the present ones.
- Some activities could be used to support more than one content concept. While an attempt was made to make the best match possible, in some cases an arbitrary decision was made as to placement. Teachers are encouraged to modify placement if it seems more appropriate for a local curriculum.
- Activities were developed in the field, not the office. As a result of individual teacher input,
 - there is not necessarily an activity supporting each concept in the content chart; but there may be more than one activity for some concepts; and
 - the level, language, and length of the activities varies widely.
- An "evaluation focus" has been suggested but individual teachers may wish to change, or add to, the evaluation process.
- Answer sheets are provided where they were provided to DPI or where they seemed necessary, but not all activities have them.
- Activities are usually addressed to one student, but group work is an appropriate modification, depending on an individual teacher's intent for the activity.
- In activities where safety hazards may exist, teachers should note "Cautions" throughout the activity and call them to the attention of students.

- Any of these materials may be copied for student use without restriction. The format was designed to facilitate reproduction in the field.
- The use of brand names (*Apple* computer, specified software) is not meant as a commercial endorsement.
- Some activities are self-contained, but most of them require lecture and/or demonstrations by the instructor.

Technology Education Content

This chart graphically depicts a content organization for the four major systems of technology—communications, construction, manufacturing, and transportation. Within each system, major instructional concepts are identified by number and letter and their specific subject matter is detailed.

The chart is the basis of the technology education program and content models presented in *A Guide to Curriculum Planning in Technology Education* (Madison, WI: Department of Public Instruction, 1988). Awareness and introductory level courses in technology education are drawn from the broad overview of the discipline presented in the first two vertical divisions of the chart. The detailed content necessary for exploratory and elective courses in each technological system comes from horizontal views across the last three divisions of the chart.

The chart is also the organizational basis for this supplemental classroom activity manual in construction. Each activity is keyed to one of the instructional concepts identified on the chart. The curriculum planning guide and activity manuals in the other three technology systems—communications, manufacturing, and transportation—are available from the Department of Public Instruction.

TECHNOLOGY EDUCATION CONTENT*

Technology	Communications	1. Graphic	A. Printing Systems and Processes B. Photographic Systems and Processes C. Industry Products D. Industry Impacts	Relief • Screen • Lithography • Gravure • Electrostatic • Ink Jet Film Imaging • Electronic Imaging Paper/NonPaper Materials • Consumable/Permanent Uses • Film • Print • Video Economic • Political • Values/Attitudes • Environment • Aesthetic
		2. Electronic	A. Telecommunications Systems and Processes B. Hard-Wired Systems and Processes C. Computer Systems and Processes D. Industry Products E. Industry Impacts	Radio • Radar • Television Telephone • Telegraph • Public-Address Systems Analog • Digital Entertainment • Information/Data • Detection/Control • Computations • Data Exchange Economics • Political • Values/Attitudes • Environment
		3. Light	A. Interactive Systems and Processes B. Passive Systems and Processes C. Industry Products D. Industry Impacts	Laser • Fiber Optics Signs • Flashing Signals Entertainment • Information/Data • Detection Economic • Political • Values/Attitudes • Environment
		4. Acoustic	A. Sonic Detection Media and Processes B. Storage and Retrieval Systems and Processes C. Industry Products D. Industry Impacts	Gas • Liquid • Solid Phonographs • Tape • Disks Information/Data • Detection/Control • Entertainment Economic • Political • Values/Attitudes • Environment
	Construction	1. Planning Processes	A. Research and Development B. Marketing C. Industrial Relations D. Financing	Initiating the Project • Developing the Project • Implementing Analyzing the Market • Establishing Strategy • Promoting • Closing the Sale Hiring • Training • Providing Benefits • Providing Career Options Appraising Property • Estimating Costs • Funding • Documenting • Budgeting
		2. Production Processes	A. Preparing the Site B. Building the Structure C. Installing Utility Systems D. Enclosing the Structure (Rough Finishing) E. Finishing the Structure (Fine Finishing) F. Completing the Site G. Servicing the Project	Clearing • Setting up Temporary Facilities • Surveying • Earthworking Setting Foundations • Building the Major Structural Elements Installing Permanent Utilities and Mechanical Plant • Providing Temporary Equipment Preparing Materials • Handling Materials and Components • Assembling in Place Prep. Subsurfaces • Prep. Materials • Handling Materials • Trimming • Removing Equip. & Debris Removing Temporary Plant and Facilities • Landscaping • Building Features • Shaping the Finishing Earth • Removing Landscaping Equipment and Debris Diagnosing/Troubleshooting • Repairing • Altering • Installing • Maintaining
		3. Managerial Processes	A. Planning B. Organizing C. Directing D. Controlling	Formulating • Researching • Designing • Engineering Structuring • Supplying • Scheduling • Routing • Storing Coordinating • Assigning • Supervising • Inspecting • Authorizing Monitoring • Reporting • Correcting
	Manufacturing	1. Input (Planning Factors)	A. Material B. Human Resources C. Capital D. Finance E. Knowledge F. Energy	Direct • Indirect Managerial • Scientific/Technical • Office/Clerical • Worker/Operator Plant • Equipment Debt • Equity Technological • Scientific • Humanities • Formal
		2. Production Processes	A. Extracting B. Primary Processes C. Secondary Processes	Drilling • Harvesting • Mining • Other Thermal • Chemical • Mechanical • Electrical Casting and Molding • Forming • Separating • Conditioning • Assembling • Finishing
		3. Managerial Processes	A. Management Functions B. Types of Managed Production C. Managed Activities	Planning • Organizing • Actuating • Controlling Custom • Intermittent • Continuous Establishing the Organization • Designing the Product • Preparing to Produce • Producing • Delivering • Serving • Controlling the System
		4. Outputs	A. Primary Outputs B. Other Outputs	Raw Materials • Industrial Goods • Finished Goods Scrap • Pollution
	Transportation	1. Planning Base	A. Elements of Transportation B. Conquest of Time and Space C. Foundation D. People Systems E. Material and Goods Systems F. Mediums	Human Mobility • Movement of Goods and People • Physical—(Natural and Human Produced) Inventions • Innovations Personalized • Mass Transit Natural Forms of Movement • Technologies of Transport Land • Water • Air • Interrelated
		2. Transporting Processes	A. Receiving B. Holding/Storing C. Loading D. Moving E. Unloading F. Delivering	People (Personalized and Mass Transit) • Materials/Goods (Bulk, Gross, Packaged) People (Personalized and Mass Transit) • Materials/Goods (Bulk, Gross, Packaged) Manual • Manually-Operated Mechanical • Mechanized • Hybrid Terrestrial (Personalized and Mass Transit, Cargo-Bulk/Unit) • Marine • Atmospheric • Space Automated/Mechanized • Manual/Mechanized • Manual • Hybrid Means of Delivering to Final Destination
		3. Technical Systems	A. Energy Sources B. Energy Conversion C. Propulsion D. Suspension E. Control F. Guidance G. Structural H. Support	Electrical • Chemical • Kinetic • Gravity • Mechanical • Magnetic • Solar • Nuclear Internal Combustion • External Combustion • Hybrid Systems Mech. Drive • Hydraulic Drive • Electric Drive • Vacuum • Gravity • Reaction • Storage Devices Mechanical • Fluid • Magnetic Velocity • Directional • Attitude • Altitude • Vehicular and System Control Guideways • On-Board and External Devices • Interrelationship of Guidance and Control Vehicular Design Considerations • Guideway Design Considerations • Support System Structures Physical Facilities • Personnel • Regulatory Factors • Operational Systems
		4. Environmental Factors	A. Human/Social B. Economic/Service C. Physical/Functional D. Aesthetics E. Interrelated	Safety • Human Values & Desires • Enhancement of Social, Recreational, Cultural Prog. & Facilities • Comfort/Convenience • Demand Responsiveness • Service for Handicapped & Disabled • Privacy Transportation Costs • Access to Employment Opportunities • Efficiency Effects on Land Use • Adaptable to Future Needs • Flexibility • Adaptable to Intermodal Operation General Appearance • Conservation of Natural Resources Noise Level • Pollution Characteristics • Neighborhood Growth and Development • Accessibility

*Based on taxonomies appearing in Thomas Wright and Leonard Sterry (co-directors). *Industry and Technology Education: A Guide for Curriculum Designers, Implementors, and Teachers*. Lansing, IL: The Technical Foundation of America.

(1A) Research and Development

Construction

Building Superstructures, an activity supporting the Construction Planning Processes concept, is designed for approximately 4 class periods.

Resources Needed

Materials

Balsa wood (5 strips, 1/8" x 1/8" x 3')
Wood glue (white or yellow)
Assorted free weights

Suggested Reference

McCrory, Todd. *Understanding and Using Technology*. Worcester, MA: Todd Davis Publications, Inc., 1986.

Objectives

The student will

understand the purpose of superstructures as a building element;
demonstrate problem-solving skills; and
design and construct a superstructure to given specifications.

Evaluation Focus

- | | | |
|------------------------------------|---|--|
| ☐ Knowledge | ☒ Problem Solving | ☒ Attitude |
| ☐ Awareness | ☐ Machine/Tool Usage | |

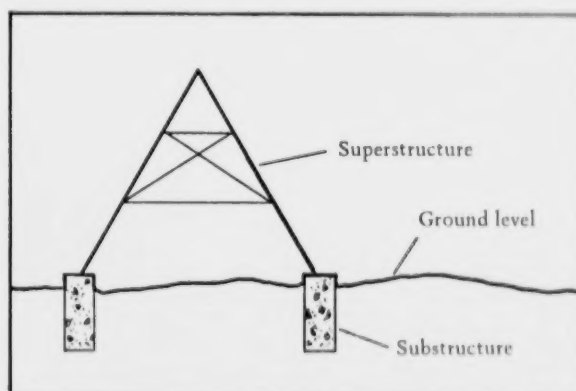
Building Superstructures

Procedure

A superstructure is the part of a structure built above the ground level. The superstructure is built on the foundation or substructure. Although towers are mostly superstructures, for example, they must be built on a foundation.

Superstructure design depends on the purpose of the structure. Buildings are used to shelter things. Bridges or highways carry traffic on top. In the case of the bridge, the foundation or substructure must hold the bridge plus the traffic.

Sometimes it's hard to identify the superstructure. In a dam or pyramid, the part that rises out of the water or sand is the superstructure.



There are three kinds of superstructures.

Mass—This type of superstructure has little or no open space inside. A good example is an earth dam.

Bearing wall—Walls are made of masonry or other materials used to enclose a space and carry or transfer the weight of the structure.

Framed—Frames may be made of wood, metal, or concrete. The frame members are columns or posts that are connected with beams. The frame alone supports the structure, although it may frequently be covered with other material (dry wall). A "frame" house is a good example.

1. On the Student Response Sheet, classify the following superstructures as mass, bearing wall, or framed:

- your home
- the school
- the local radio tower
- a bridge
- your body
- earth sound barriers along a freeway

2. Using no more than 15' of 1/8" square balsa wood, construct a tower that meets the following specifications:
 - wood must be glued (no metal fasteners)
 - wood cannot be laminated
 - structure rests on three points only
 - height of 7"
 - supports 20 pounds (**Note:** This means the top of the tower will have to be *flat*.)
3. When you have finished building your tower, gently add weights to test its strength. When your tower is holding 20 pounds, you may stop testing or continue to add weights until it breaks (destructive testing). If you do this, record the largest weight your tower held before breaking. Use the Student Response Sheet for your answer.

Building Superstructures

Name _____

Class/Period _____

1. Superstructure classification

your home _____

the school _____

the local radio tower _____

a bridge _____

your body _____

earth sound barriers

along a freeway _____

2. Heaviest weight your tower supported _____

(1A) Research and Development

Construction

Floor Plans, an activity supporting the Construction Planning Processes concept, is designed for approximately 5 class periods.

Resources Needed

Equipment

Architect's scale

Materials

Standard drawing materials

Graph paper (1/4" squares)

Suggested Reference

Architectural drafting books

Objectives

The student will

understand architectural symbols and drawings;

read a 1/4" scale architect's ruler;

draw a floor plan sketch of a living room; and

draw a floor plan to scale of a living room.

Evaluation Focus

☒ Knowledge

☐ Problem Solving

☐ Attitude

☐ Awareness

☒ Machine/Tool Usage

Floor Plans

Procedure

For millions of adults, the ability to measure accurately is an essential requirement of their occupations. How else could people plan and build the multitude of things that we use. Whether it be a bridge, a machine, or a toy, people who design and construct the item have to have the ability to measure accurately.

We can measure with great exactness—sometimes to the accuracy of a thousandth of an inch or even a ten-thousandth of an inch. Most beginning work does not require such exactness, but every beginner must be able to use the common ruler. This activity will improve your skill in using a ruler and scale, your ability to acquire information from a floor plan drawing, and your understanding of how construction and building information can be stored by use of such a drawing.

1. Begin by reading the section entitled "How to Use an Architect's Scale" and by studying the Common Architectural Symbols chart and the sample drawing of a three-bedroom house.

How to Use an Architect's Scale

Measuring is not just a skill for the scientist or highly talented technician; it is a skill that is needed by all people. In many ways, learning to measure is just as basic a skill as learning to read and write. In any class of a technical nature, you must be able to measure accurately.

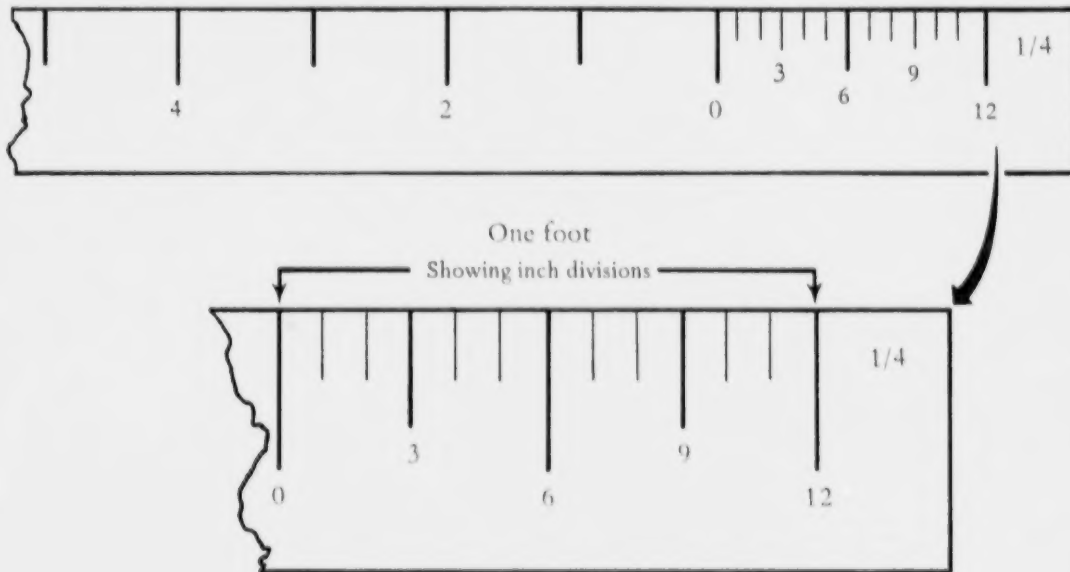
Length is measured to find the distance from one point to another point, which is called linear measurement. The system used in the United States for measuring length involves yards, feet, and inches with fractions. A basic tool for measuring length in this country is a 12" scale (or ruler). Each inch is divided into 16 equal divisions. Many draft persons and technicians still use this scale for measuring length.

The architect's scale is one of several types of specific scales used in various occupations. (Other scales classified according to their use are the mechanical engineer's scale, civil engineer's scale, and metric scales.)

In this activity, you will use the architect's scale because of its similarity to the 12" ruler and because this scale is used in machine drawing, as well as in architectural drawing.

2. Get an architect's scale and examine it. The scale has several divisions representing feet. The end unit on the scale represents inches. Notice that the scale has three sides with a number of different size markings on each side. For this activity, you will be interested in one side of the scale—the 1/4" side.

3. Turn the scale to the side with the fraction $\frac{1}{4}$ marked on it. This end of this side of the scale should look like the example.



The scale that you are looking at is a $\frac{1}{4}$ " architect's scale, where $\frac{1}{4}$ " represents one foot. This type of scale is used to reduce the size of a large object (such as a house, so it can be drawn proportionally to a more convenient size).

4. Notice the marks and numbers to the left of the zero. They represent feet. Every other foot is identified with a number (2, 4, 6, etc.). The odd foot markings are between the even marks but are not identified with a number.

The inch markings are to the right of the zero. Each mark represents one inch. The diagram shows how a foot is divided into 12 equal parts, with each part representing one inch. You need to understand this system before measuring to scale is possible.

Using the Scale With a Floor Plan

The following example will help you to use a $\frac{1}{4}$ " scale to measure room sizes on the floor plan.

1. Find Bedroom 1 on the floor plan.

2. Line up the zero end of the scale with the inside of one of the walls. (See Figure A.)

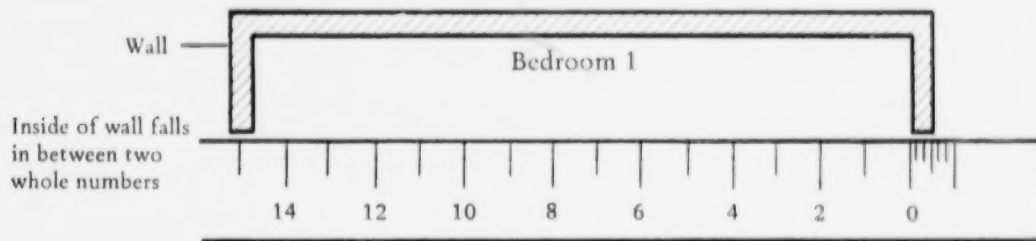


Figure A

3. Read the scale by following the markings across the room to the other inside wall. (**Note:** Your ruler must be parallel to the wall.)
4. If the inside of the wall falls between the whole numbers representing feet, move the scale back to the last whole number and read the number of inches at the zero end of the ruler. (See Figure B.) This will give the exact linear measurement of the wall in feet and inches (14' 10" in the example).

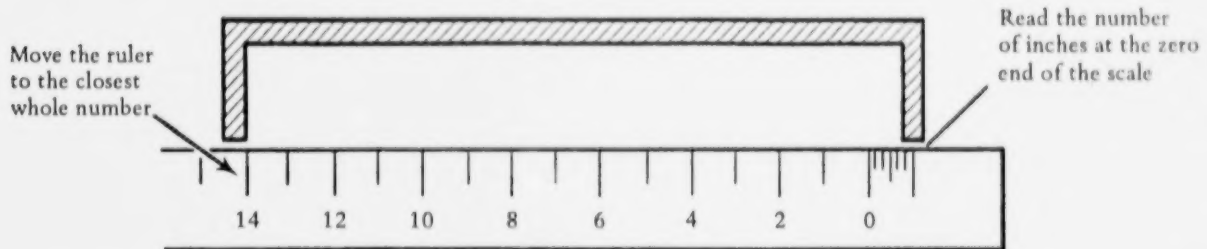
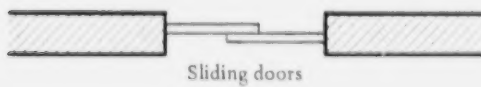
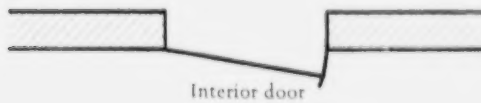
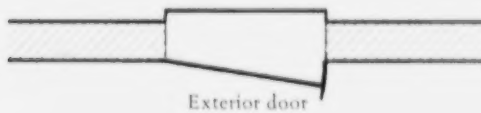
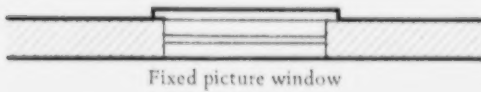
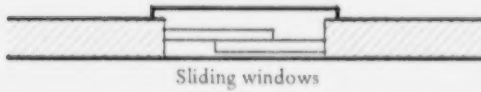
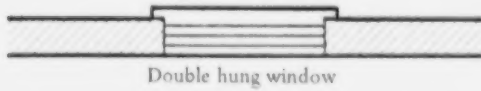


Figure B

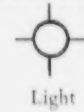
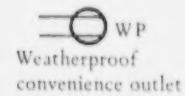
5. Two measurements are needed to describe a room's size; they are the length and width of a room. They are usually expressed with an "x" between the two measurements, with length given first. Thus, 14'10" x 11' means a room is 14'10" long and 11' wide.

Common Architectural Symbols

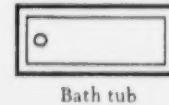
Window and door symbols

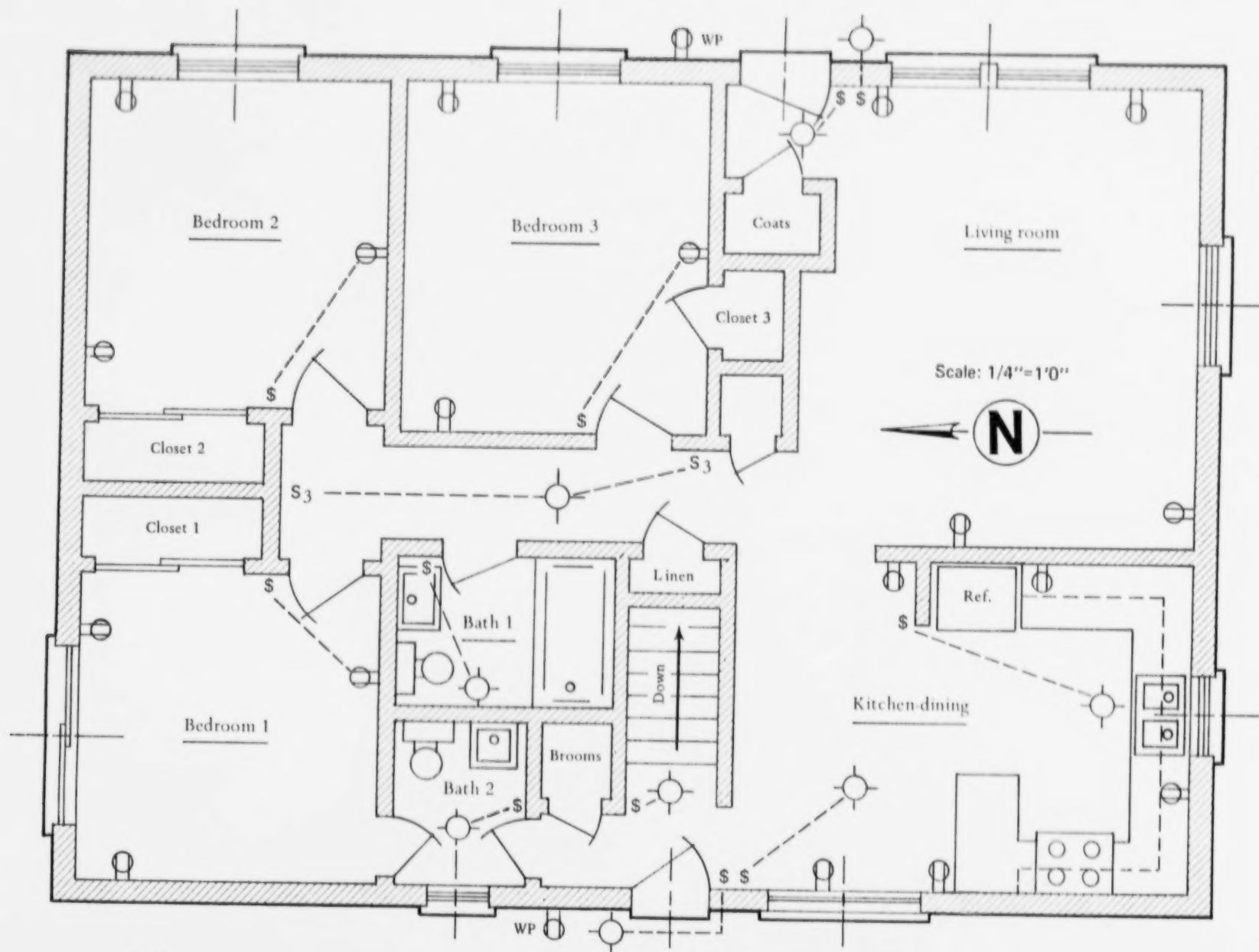


Electrical



Plumbing





Questions

Answer the questions, using the architect's scale and the sample layout. Put your answers on the Student Response Sheet.

1. How many square feet are there in the house? (Measure the width and the length. Multiply the width by the length in feet. This gives you the square feet.)
2. If it costs \$50.00 per square foot to build the house, what would the cost be?
3. What is the size of Bedroom 1?
4. How many square feet are there in Bedroom 1?
5. How many square feet are there in the living room? Do not include the entryway.
6. According to the symbol sheet, what types of windows are used in Bedroom 1?
7. What type of windows are used in the living room?
8. What type of window is used on the west wall of the kitchen?
9. How wide is the window on the west wall of the kitchen?
10. The main entrance to the house is on the east side. How wide is the door?
11. How wide is the door on the west side of the house?
12. What type of door is used for Closet 1?
13. There are three conflicts with doors. (If you open two doors at the same time, they will interfere with each other.) Find one of them and tell where it is?
14. When the carpenter builds the house, he lays out windows and doors by measuring to their centers. How far in feet and inches is it from the center of the window in Bedroom 1 to the center of the window in Bedroom 2?
15. For efficiency, the distance between the sink and the refrigerator should be between 4' and 7'; the distance between the sink and range should be between 4' and 6'; and the distance between range and refrigerator should be between 4' and 9'. Measure these distances. Are any of them unsatisfactory? If your answer is yes, which one(s)?
16. All closets are standard depth, with the exception of the broom closet and the linen closet. How deep are the clothes closets?
17. Is there a basement in the house? How can you tell?
18. The bathtub is standard size. Measure it and give the width and length.

19. Base cupboards in the kitchen should be a standard 24" deep. Do they comply with the standard?
20. Bedroom doors should not be less than 2'6" wide to allow furniture to be moved. Are any of the bedroom doors smaller than 2'6" in width? If your answer is yes, which bedroom? If your answer is no, leave the answer space blank.
21. Bedroom 2 is to be carpeted. How many square yards of carpeting are needed? (Find the number of square feet in Bedroom 2. Write it down. Divide this number by 9, which is the number of square feet in a square yard.)
22. How many convenience outlets are there?
23. How many of the convenience outlets are controlled by a switch?
24. How many weatherproof outlets are there?
25. How many lights are controlled by switches?
26. How many lights are controlled by three-way switches?
27. Where is the telephone located?
28. How many outlets are outside?
29. Are there any outside lights?
30. If so, how many?
31. How many outside (weatherproof) electrical outlets are there?
32. How many outlets in the living room?
33. How many outlets in the kitchen/dining room?
34. How many phone outlets are used in this floor plan?
35. How many outlets in Bedroom 1?
36. How many outlets in Bedroom 2?
37. How many outlets in Bedroom 3?
38. How many outlets in bathroom and hall?
39. Total number of switches to wire this house?
40. Total number of outlets in the house?

41. If each outlet costs \$2.25, what is the total price for outlets?
42. Are there any lights in the closets?

How to Draw a Floor Plan

After you finish answering the questions about the floor plan, you should be ready to draw a floor plan of your own living room. First measure this room in your home. Then draw a rough sketch (a drawing not to exact scale), including

- the walls, with accurate dimensions of the width and length of the rooms;
- windows and doors, with accurate dimensions of both the location and width of each, measured to the center of each one; and
- electrical switches and outlets.

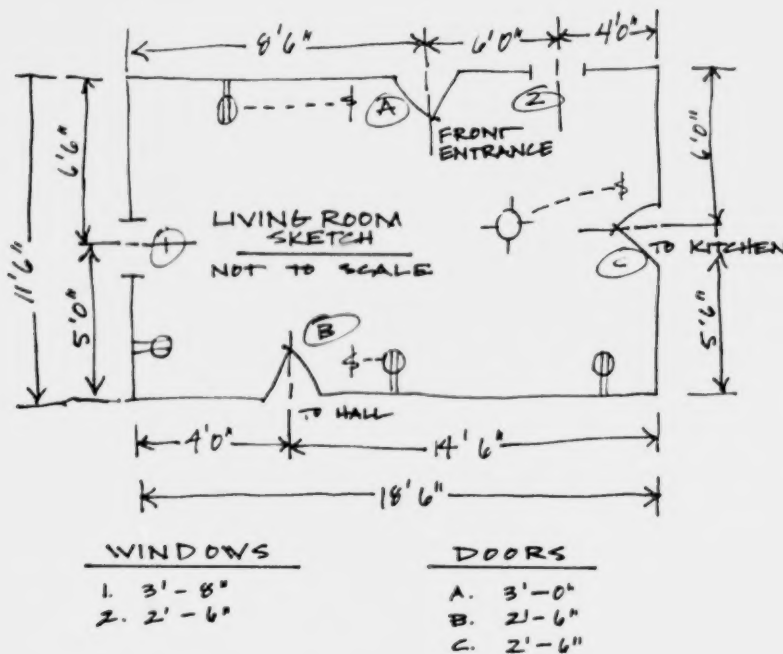
This is only a sketch of your living room. Do not include furniture unless something is built-in, like a book case. For your sketch, just use a line for a wall. You will draw in the thickness of the wall when you make your final drawing. Add windows and doors, with accurate measurements included on your sketch. (**Note:** Remember to measure to the center of windows and doors. Draw a center line to show where the center is.) (See example.)

Draw a line, called a dimension line, from the corner of the room to the first center line. Write in the distance on the top of this line. Draw in small arrowheads at the ends of the line. Draw another dimension line to the next center line, and write in the distance and draw arrows again. Do this until all the dimensions are in.

Add switches and convenience outlets, using the proper symbols.

Number your windows. Identify doors with letters. Make a small chart, giving the widths of the windows and doors.

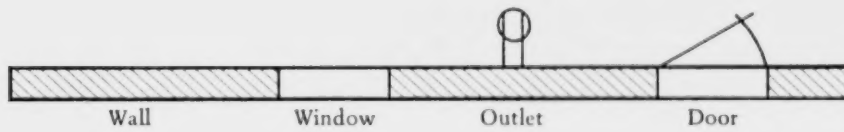
Your sketch should look something like this.



Once you have all the features included and have measured all the distances, the next step is to draw a scale drawing.

Making a Floor Plan to Scale

You can make a floor plan to scale using the sketch that you made of your living room and a piece of graph paper. The squares on the graph paper are $\frac{1}{4}$ " in size. The scale you will be using for your drawing is $\frac{1}{4}$ " equals 1', or one square equals 1'. Using this scale, draw your living room on the graph paper. (**Note:** If your living room is 24' x 12', count 24 squares one way and 12 the other way.) Be sure to locate doors, windows, and electrical outlets.



When you have completed the drawing, have your instructor compare it to your sketch.

Floor Plans

Name _____

Class/Period _____

1. Width _____
 Length _____
 _____ square feet

2. Square feet _____
 x \$50.00
 _____ cost

3. Width _____
 Length _____

4. _____ square feet

5. Width _____
 Length _____
 _____ square feet

6. _____

7. _____

8. _____

9. _____ ft. _____ inches

10. _____ ft. _____ inches

11. _____ ft. _____ inches

12. _____

13. _____

14. _____ ft. _____ inches

15. _____. If your answer was no, go on to Question 16. If your answer was yes, which one? _____

16. _____ ft. _____ inches

17. _____. How can you tell?

18. _____ ft. _____ inches wide
 _____ ft. _____ inches long

19. _____

20. _____. If your answer was no, go on to Question 21. If it was yes, which bedroom?

21. Width _____
 Length _____
 _____ square feet

9) _____

22. _____

23. _____

24. _____

25. _____

26. _____

27. _____

28. _____

29. _____

30. _____

31. _____

32. _____

33. _____

34. _____

35. _____

36. _____

37. _____

38. _____

39. _____

40. _____

41. _____

42. _____

Floor Plans

1. Width 28
Length 38
1064 square feet
2. Square feet 1064
x \$50.00
\$53,200 cost
3. Width 10'0"
Length 10'3" (10.25')
4. 102.5 square feet
5. $9 \times 13 = 117$ or 13
 $6 \times 12 = \frac{72}{189}$ x $\frac{15}{195}$
 $\frac{6}{18.9}$
6. Sliding
7. Double hung
8. Fixed picture
9. 5'0"
10. 3'0"
11. 2'6"
12. Sliding
13. (A) East entrance (B) West entrance (C) Bedroom 3
14. 10'6"
15. No. If your answer was no, go on to Question 16. If your answer was yes, which one?
16. 2'0"
17. Yes. How can you tell? Stairs go down.
18. 2'6" wide
5'0" long
19. Yes
20. No. If your answer was no, go on to Question 21. If it was yes, which bedroom?
21. Width 10'
Length 10'9" (10.75')
107.5 square feet

$$9 \overline{)107.5} \quad \begin{array}{r} 11.9 \end{array}$$

- 22. 20
- 23. 3
- 24. 2
- 25. 8
- 26. 1
- 27. North wall of kitchen-dining room
- 28. 1
- 29. Yes-1
- 30. 1
- 31. 1
- 32. 4
- 33. 5
- 34. 1
- 35. 3
- 36. 3
- 37. 3
- 38. None
- 39. 13
- 40. 19
- 41. \$42,45
- 42. No

(1A) Research and Development

Construction

Paper Platform, an activity supporting the Construction Planning Processes concept, is designed for approximately 2 class periods.

Resources Needed

Equipment

Assorted free weights (up to 150 pounds)

Materials

Scissors
White glue
Ruler

Suggested References

Gourley, Theodore J., and C. Samuel Micklus. *Creative Problem Solving*. Glassboro, NJ: Creative Competitions, Inc., 1984.

Gourley, Theodore J., and C. Samuel Micklus. *Problems! Problems! Problems!* Glassboro, NJ: Creative Competitions, Inc., 1984.

Both available from
Creative Competitions, Inc.
P.O. Box 27
Glassboro, NJ 08028

Objectives

The student will

exercise creative problem-solving abilities;
employ structural design and construction techniques; and
design and build a structure, within specific limitations, that will hold the heaviest possible weight.

Evaluation Focus

☐ Knowledge
☐ Awareness

☒ Problem Solving
☐ Machine/Tool Usage

☐ Attitude

Paper Platform

Procedure

Design Problem

Using only one sheet of standard 8-1/2" by 11" paper and white glue, construct a platform that will support as much weight as possible.

Design Considerations

Only use one sheet of paper.

Only use white glue (or yellow).

Clamping devices to aid in construction may not be used.

Platform must be 3" tall, plus or minus 1/8".

Time for construction is one class period.

Testing

Your platform will be allowed to dry a minimum of 12 hours. You will then place your platform on the floor and test the height with a ruler. You may then begin placing weights on top of your structure in any manner you choose until it collapses. The weight last held for more than 30 seconds will be considered the heaviest weight your platform supported.

(1A) **Research and Development**

Construction

Passive Solar Home, an activity supporting the Construction Planning Processes concept, is designed for approximately 5 class periods.

Resources Needed

Equipment

Standard hand tools

Materials

Hardboard

Insulation

Plastic film

Thermal mass material (bricks, water containers)

3/4" expanded polystyrene insulation

White glue

Tempera paint

Thermometer

Suggested References

Anderson, Bruce. *Solar Energy: Fundamentals of Building Design*. New York: McGraw-Hill, 1977.

Sands, Jonathon. *Practical Solar Heating Ideas with Sunlight*. Manchester, NH: Kallwall Corporation, 1975.

Objectives

The student will

- explain how the angle of the sun to the earth affects passive solar heating;
- describe the concepts involved in using thermal mass to store solar heat;
- explain how the greenhouse effect works;
- design and build a model house that uses passive solar heating; and
- evaluate and model house's heat collection effectiveness.

Evaluation Focus

- | | | |
|------------------------------------|---|--|
| ☐ Knowledge | ☒ Problem Solving | ☒ Attitude |
| ☐ Awareness | ☐ Machine/Tool Usage | |

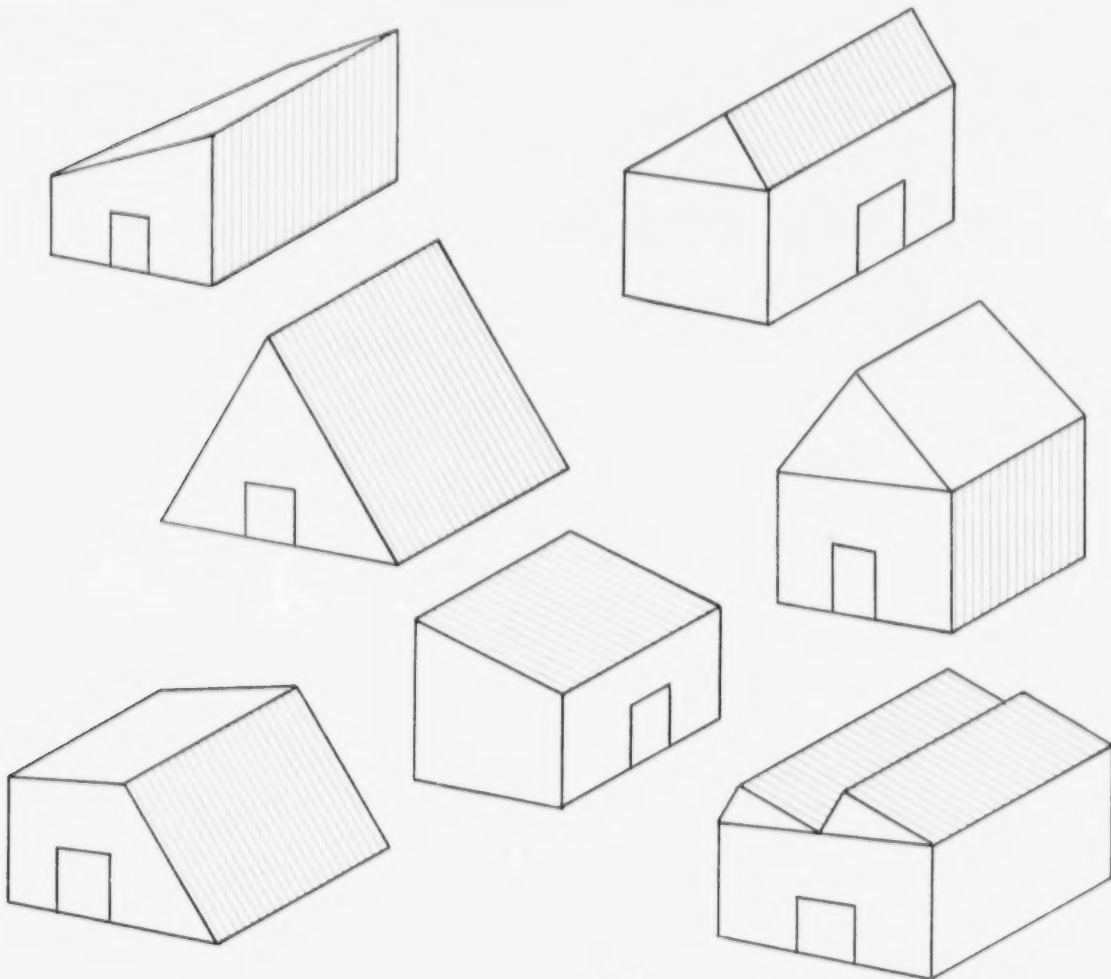
Passive Solar Home

Procedure

In some climates, there are economic advantages to building a home that uses the sun's energy for heating. Passive solar heating systems are extremely efficient because they do not require another form of energy, such as electricity, to operate. The purpose of this activity is to design and build a small model house that uses passive solar heating. The storage of thermal energy collected from the sun will require some form of thermal mass, such as masonry (brick) or liquids (containers filled with water).

The sun's heat energy can be collected by allowing the sunlight to come through plastic windows in your model. By building thermal mass into your house, heat energy can be stored in the house. During this activity, you will be able to use either bricks or cans of water as thermal mass. The house will be built on a hardboard base, and rigid plastic insulation will be used for the roof and walls. Design your model house around the type of thermal mass you will be using for heat storage.

Examples of Passive Solar House Designs



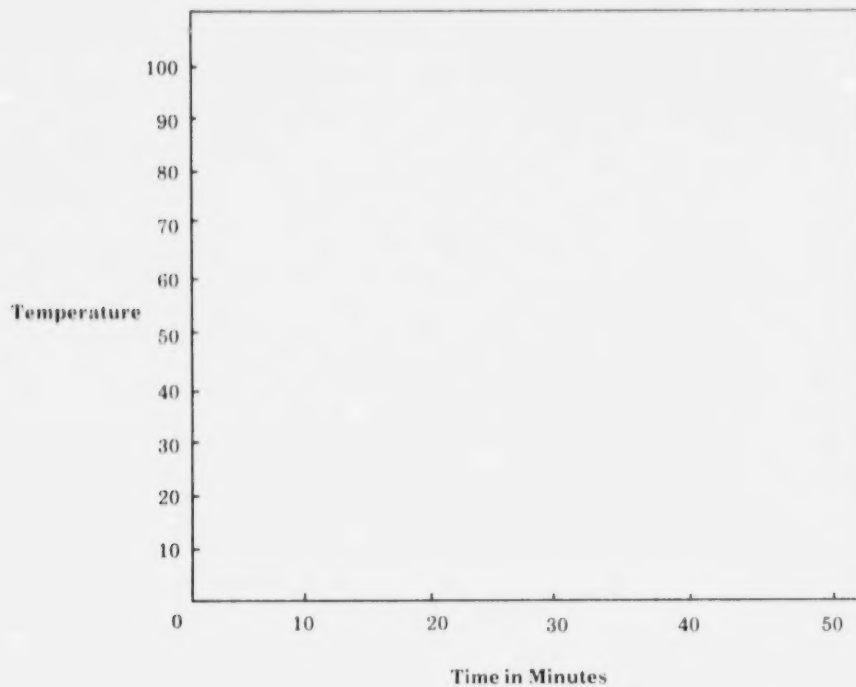
1. Make several (at least four) sketches of house designs that you think will collect the sun's energy.
2. Pick the design you think is best and draw a three-view drawing with dimensions.
3. Make a materials list for the materials you will need to build your model house. Use hardboard for the base, 3/4" insulation for the walls and roof, plastic film for the windows, and bricks or water-filled cans for the thermal mass. Use white glue to put the model together, and paint with water-base tempera paint.
4. Construct your model. Be sure to follow all safety rules and procedures. Only simple hand tools should be needed to build your model house.
 - A. Cut a base for the model out of 1/4" hardboard.
 - B. At this time, put your thermal mass into place. Bricks can be placed on the floor or against a wall. Cans of water can be placed near the window or more toward the interior. Locate the thermal mass so that sunlight will strike it through the windows.
 - C. Paint the thermal mass with a dark color because it will absorb the sun's rays better than a light color.
 - D. Cut walls and roof sections from 3/4" expanded polystyrene according to your plans. Also, cut your window openings.
 - E. Cut window coverings 1" over-sized from clear plastic film, and glue them to the interior side of your wall or roof sections.
 - F. Assemble the wall and roof sections around your thermal mass. Make sure that you are able to remove a roof or wall panel of your model house so that you can put in and take out the thermometer used in testing your house.
 - G. Paint the interior and exterior of your model, and let dry.
 - H. Now your model passive solar house is ready for testing.
5. Test your model. All models will be tested on the same day. Place a thermometer in your house. Face your collecting wall or roof toward the sun.
6. Every five minutes for the first 25 minutes of the test period, record the temperature of your model house.
7. At the end of the first 25 minutes, pick up your model and take it in the classroom. Continue recording the temperature in your house during the last 25 minutes of class.
8. On the Student Response Sheet, graph your results, plotting temperature on the vertical axis and time on the horizontal axis.
9. Answer the questions on the Student Response Sheet.

Passive Solar Home

Name _____

Class/Period _____

1. Express your testing results on the chart by plotting the temperature at regular time intervals.



2. How did the angle of the sun to the earth affect your house model?
3. What purpose did the thermal mass serve?
4. What purpose did the clear film serve?

(1A) Research and Development

Construction

Truss Design, an activity supporting the Construction Planning Processes concept, is designed for approximately 3 class periods.

Resources Needed

Equipment

Coping saw
X-acto knife

Materials

Wood strips (1/8" x 1/4" x 48" to represent pieces of 2"x 4" that are 64' long on a scale of 3/4" = 1'
Wood glue (white or yellow)
File folders (use pieces cut to 1/2" x 1" for gussets)

Objectives

The student will

understand problems faced in designing bridges, dams, roofs, and towers;
demonstrate problem-solving skills; and
design a truss to given specifications.

Evaluation Focus

- ☐ Knowledge
- ☐ Awareness

- ☒ Problem Solving
- ☐ Machine/Tool Usage

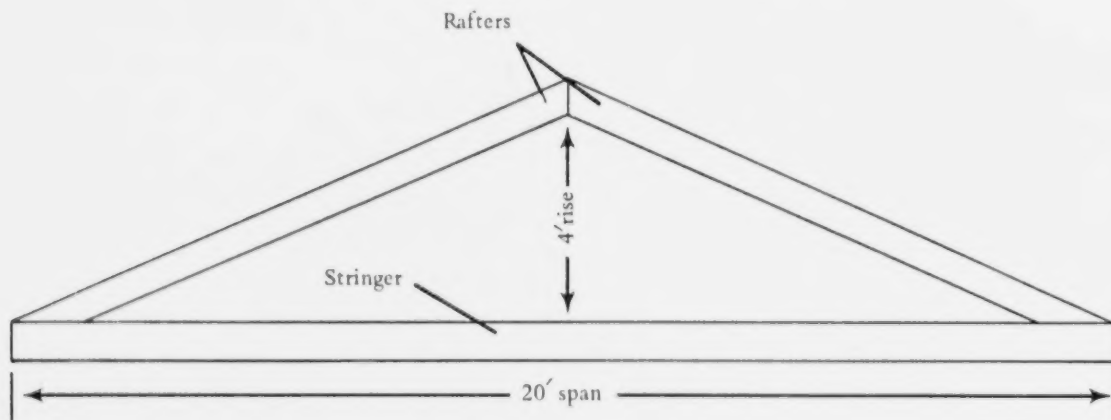
- ☐ Attitude

Truss Design

Procedure

Civil and construction engineers are faced constantly with the problem of designing structures such as bridges, dams, roofs, and towers. Sometimes these structures have failed. Bridges have collapsed, or buildings have fallen down. Our safety depends on how well engineers, draftspersons, carpenters, inspectors, and other workers do their jobs. At the same time, a structure should not be designed so that it is much stronger than it needs to be. This would cost too much money.

Construction workers are faced with the same challenge that you will be facing in this activity—to build the strongest possible structure with a minimum amount of material. Your task is to design and test the strongest possible truss that you can with the allowed materials.



1. You will be given these materials. You may not use any other materials.

strip of wood that measures $\frac{1}{8}$ " thick by $\frac{1}{4}$ " wide by 48" long (This represents a piece of 2" x 4" that is 64' long at a scale of $\frac{3}{4}$ " = 1'.)

glue

coping saw and X-acto knife

$\frac{1}{2}$ " x 1" pieces of paper cut from file folders to use as gussets

2. Lay out a drawing of the truss, utilizing the scale $\frac{3}{4}$ " = 1' and the following specifications:

the stringer and rafters will use 42' of the 64';

the remainder of your material will be utilized to gain maximum strength by placement of pieces inside the rafters and stringers; and

all joints must be butt joints.

3. Use the drawing to lay out and cut wood pieces to proper sizes and angles.
4. Assemble pieces with glue, utilizing the paper gussets.
5. Proceed with testing by supporting both ends and adding weight to the middle until it fails. Record the heaviest weight your truss was able to hold.

(2B) Building the Structure

Construction

Site Layout, an activity supporting the Construction Production Processes concept, is designed for approximately 2 class periods.

Resources Needed

Equipment

- Sledge hammer
- Claw hammer
- Handsaw (cross cut)
- Builder's level
- Plumb bob
- Heavy cord or twine

Materials

- Batter board stakes (2" x 4" x 3')
- Ledger boards (1" x 6" x 6')
- Braces (1" x 4" x 6')
- Nails (8d box)
- Corner stakes (2" x 2" x 1')

Instructor's Note

This activity requires that you have prepared a suitable site, such as an athletic field, in advance. Certain procedures may also require lecture and demonstration activities if your students have not previously learned them. Students can easily work in pairs or in teams for this activity.

Suggested References

- Durbahn, Walter E., and Elmer W. Sundberg. *Fundamentals of Carpentry*. Vol. 2. Chicago, IL: American Technical Society, 1969.
- Mix, Floyd, and E.C. Pritchard. *Practical Carpentry*. Homewood, IL: Goodheart-Wilcox Co., Inc., 1963.
- Wagner, Willis H. *Modern Carpentry*. Homewood, IL: Goodheart-Wilcox, Inc., 1969.

Objectives

The student will

- locate and stake out property boundary markers;
- erect batter boards;
- locate the position of buildings within a property and make sure that local building regulations are not violated;
- square corners using the 3-4-5 method;
- use a plumb bob to establish the position of corner stakes;
- use a builder's level and establish points having the same elevation and also establish grades; and
- check the accuracy of the setting out of a building site.

Evaluation Focus

- | | | |
|---|--|--|
| ☒ Knowledge | ☐ Problem Solving | ☒ Attitude |
| ☐ Awareness | ☒ Machine/Tool Usage | |

Site Layout

Procedure

Using the layout plan, you will be marking property and building sites. Job criteria are given for you to check your finished work.

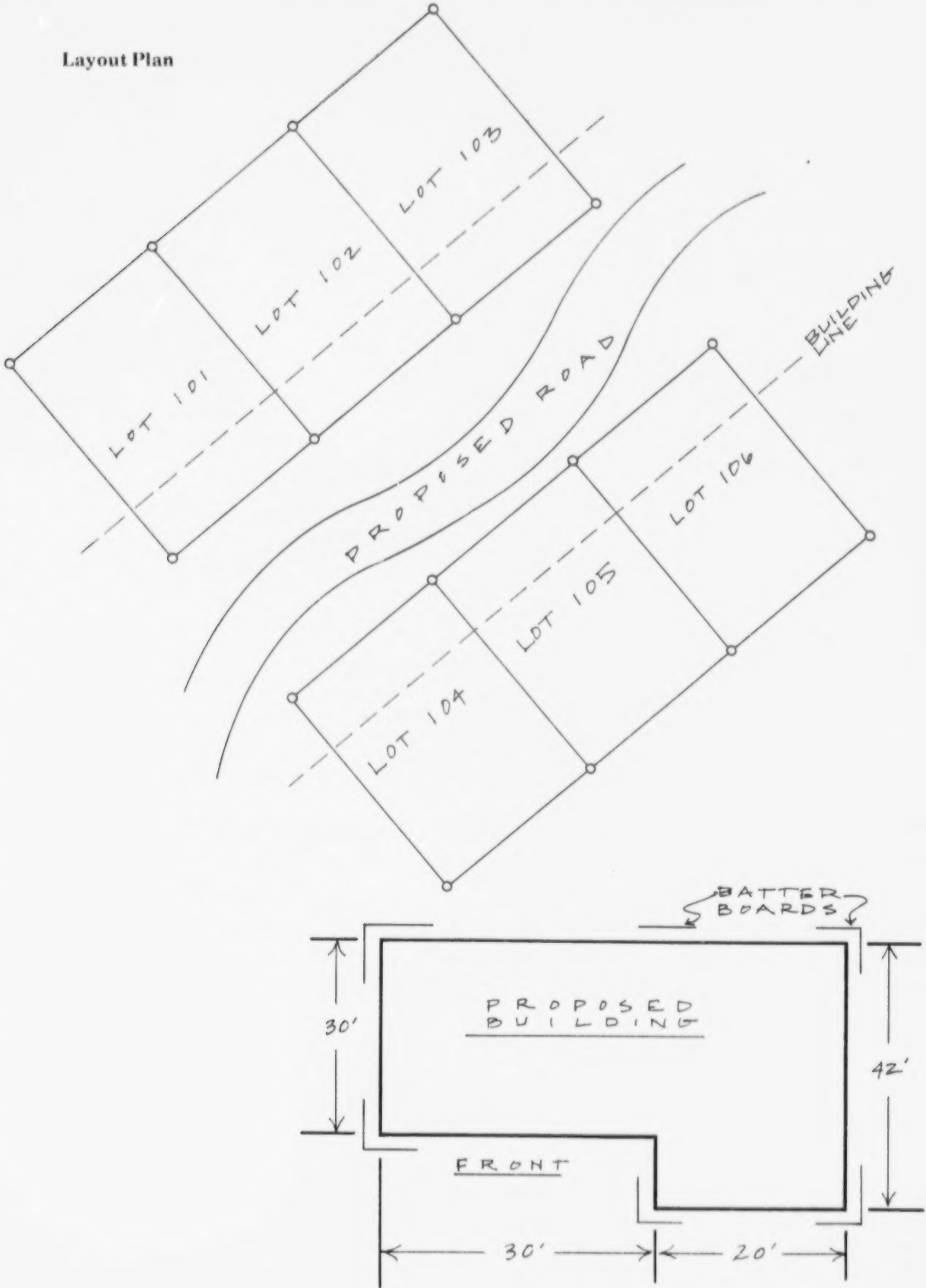
Read each step in the procedure carefully before you attempt to do that step. All steps are to be done in order.

Check off each step as you complete it.

- ☐ 1. Check out materials.
- ☐ 2. Cut materials to size.
- ☐ 3. Locate property boundary markers.
- ☐ 4. Locate approximate position of building lines inside boundary lines. Note local building regulation conditions.
- ☐ 5. Drive batter board stakes at the corner of building lines; make sure stakes are at least 4' outside the building lines.
- ☐ 6. Use builder's level to make sure all ledger boards are at the same elevation.
- ☐ 7. Attach ledger boards to stake and brace batter boards.
- ☐ 8. Measure location of building lines from property lines and mark position on ledger boards using pencil.
- ☐ 9. Attach string between points on ledger boards to locate building lines.
- ☐ 10. Use a 3-4-5 method for checking corners.
- ☐ 11. Shift strings on the ledger boards until corners are square and mark by saw kerf at exact locations.
- ☐ 12. Run string from saw kerf to saw kerf and locate corners of building. Use plumb bob to mark position of corner stakes.
- ☐ 13. Drive nails on corner stakes to locate exact position of corners.
- ☐ 14. Use builder's level and establish grade levels, moving the instrument at least once. Close by returning to datum position. Do not shift position of instrument until instructor has checked readings.

Job Criteria	Yes	No
Property boundary markers located correctly	☐	☐
Position of building located correctly within property		
(a) front of building behind building line	☐	☐
(b) sides at least 10' from boundary	☐	☐
Batter boards located at least 4' from building line	☐	☐
Corner stakes located correctly $\pm 1/8"$	☐	☐
Corners square $\pm 1/8"$ when checked on diagonals	☐	☐
Sides of building correct $\pm 1/8"$	☐	☐
Closure on builder's level $\pm 1/8"$	☐	☐
All ledger boards at same elevation	☐	☐
All batter boards firmly fixed to the ground and braced correctly	☐	☐

Layout Plan



(2C) Installing Utility Systems

Construction

Plumbing Techniques, an activity supporting the Construction Production Processes concept, is designed for approximately 5 class periods.

Resources Needed

Facility

Wall section module with laundry sink setup (see Figure 27)

Equipment

Assorted plumbing tools (pipe vise, cutter, threader, reamer, wrench, tubing cutter)

Other tools (brace, propane torch, assembly holding fixture, hacksaw, sloyd knife, screwdriver)

Sections of 1/2" galvanized or black iron water pipe with 1/2" couplings

Sections of copper tubing and fittings

Sections of polyvinyl chloride (PVC) pipe and fittings

Assorted T-fittings and elbows

Single tub laundry deep sink

Drain trap

Air chambers (two)

Faucet assembly

Spark igniter

Materials

Cutting oil

Teflon tape

Solid core 50/50 wire solder, flux, brush

Solvent brush

PVC pipe cleaner and joint solvent (cement)

Abrasive paper or cloth (fine grit)

Steel wool

Assorted rags

Objectives

The student will

learn about different types of plumbing pipes and how to work with them;
learn how to use various plumbing tools;
practice various plumbing techniques; and
install a laundry sink.

Evaluation Focus

- | | | |
|---|--|--|
| ☒ Knowledge | ☐ Problem Solving | ☒ Attitude |
| ☐ Awareness | ☒ Machine/Tool Usage | |

Plumbing Techniques

Procedure

Indoor running water is a luxury that we take for granted today, but there are people who have to use an outdoor privy and have to carry water indoors from an outside well or other source. More modern plumbing systems rely on a network of pipes to carry water from the source (well, lake, river) to the household tap.

Over the years, many materials have been used to form the pipes to distribute water. Early water mains were merely hollowed logs. Later, cast iron and black iron pipes were used. Until 30 years ago, the most common pipe used in buildings for fresh water was galvanized iron pipe. Copper and brass have been used recently in some new homes, and plastic pipe especially is gaining in popularity because it is easy to work with, inexpensive, lightweight, clean, and durable. Each type of pipe system is fabricated differently. In this activity, you will assemble pipes made from all three materials.

The work of designing and assembling plumbing systems is best done by master and journey-level plumbers. Both men and women are finding rewarding careers in the plumbing trade. The route to becoming a professional plumber is through an apprenticeship. If you want to know more about careers in the plumbing trade, ask your teacher or your librarian to help you find reference materials on the subject.

Threading Galvanized Iron Pipe

Pipes are joined together with threaded fittings or pipe. Parts referred to as female have their threads located on the inside of the tube or fitting. Male parts have external threads (see Figure 1). Most parts needing female threads are purchased threaded, so it is rare that internal threads would need to be made. Pipe, however, often needs to be cut to fit a specific space, and it must be threaded after cutting. Threads on water pipes are tapered (see Figure 2). This tapering causes the threaded joint to seal as it is tightened. In this lesson, you will cut and thread some 1/2" water pipe. Follow the directions carefully.



Figure 1



Figure 2

Tools

You should become acquainted with the plumbing tools that you will be using for this activity (see Figure 3).

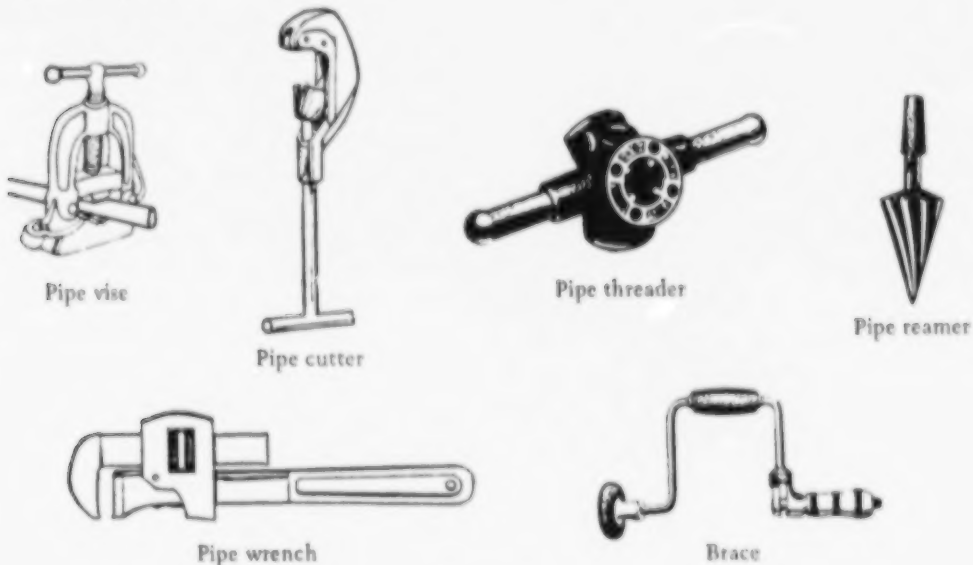


Figure 3

You will need the following equipment and materials:

section of 1/2" galvanized or black iron water pipe with 1/2" coupling
cutting oil
Teflon tape

1. Secure a pipe section, mount it in a vise, and remove the coupling. Use a pipe wrench (see Figure 4). Watch how the pipe wrench grips the coupling.

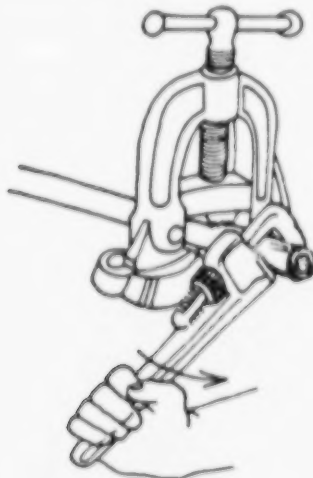


Figure 4

2. Move the pipe so that 8" of it projects from the vise.
3. Make a pencil mark 2" from the end of the pipe.
4. Open the pipe cutter so that it will slide over the pipe to the 2" mark. (Be careful not to damage the cutter wheel by hitting irregularities or threads on the pipe.)
5. Twist the T-handle until the cutter wheel *touches* the pipe.
6. Swing the cutter around the pipe, moving toward yourself, until the cutter wheel has scored the pipe all the way around with a *single cut* (see Figure 5).

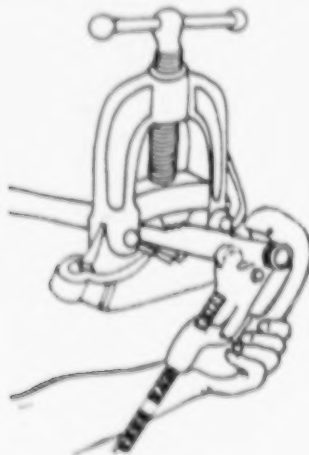


Figure 5

7. Tighten the T-handle about a quarter turn and swing the cutter around again at least twice. You will feel the difference in the "pull" when the cutter has completed this scoring and when it is time to again tighten the handle.
8. Repeat Step 7 until the pipe is cut off.
9. Use a pipe reaming bit and a brace to remove the burr inside the pipe (see Figure 6). Why do you suppose that it is necessary to remove the burr since it will be covered by the fitting anyway?

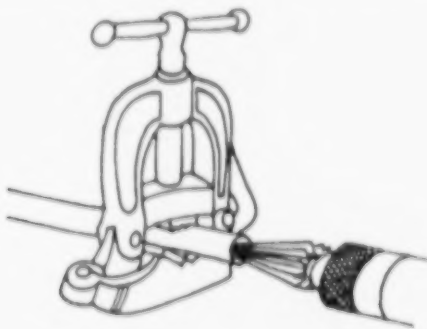


Figure 6

10. Place some newspaper sheets on the floor to catch the oil and shavings from the next few operations.
11. Put two drops of cutting oil on the end of the pipe.
12. Select the proper thread cutter and place the guide hole over the pipe (see Figure 7).



Figure 7

13. Slowly turn the pipe cutter clockwise until the cutter teeth engage the pipe (see Figure 8). Continue to turn the pipe threader until it binds.

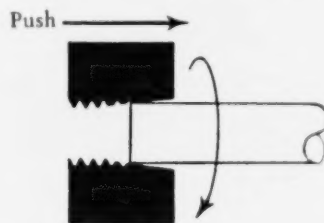


Figure 8

14. Back the cutter off (counterclockwise) about a quarter turn. This will break the metal shaving that is created by cutting the threads. (**Note:** This must be done.)
15. Apply more oil (two drops) to the end of the pipe.
16. Turn clockwise until binding occurs again (usually about a half turn), and then back up to break the shaving.
17. Repeat Steps 15 and 16 until the new threads project through the cutter for the distance of one thread.
18. Back the pipe threader off the pipe.
19. Clean up.
 - A. Wipe the pipe and all of your tools with a rag.

► Caution

The metal shavings will be very sharp.

- B. Sweep all shavings onto the newspaper or into a dustpan. Throw newspaper and shavings away.
 - C. Put all tools and materials away.
20. Wrap Teflon tape around the threads at least twice (see Figure 9).

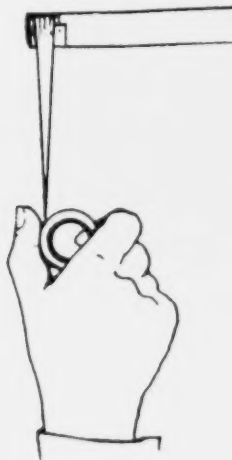


Figure 9

21. Turn a coupling onto the threads by hand, and then tighten with a pipe wrench.
22. Turn in your work.

Sweat Soldering Copper Pipe

The fresh water lines in many homes today are made of copper metals (copper and/or its alloys). Because copper pipes have thin walls, and because copper pipes are soft, threading is not practical. Pipes made of copper are most often joined by sweat soldering a copper fitting to copper pipe. Follow instructions *exactly* and you should have little trouble sweat soldering.

Tools

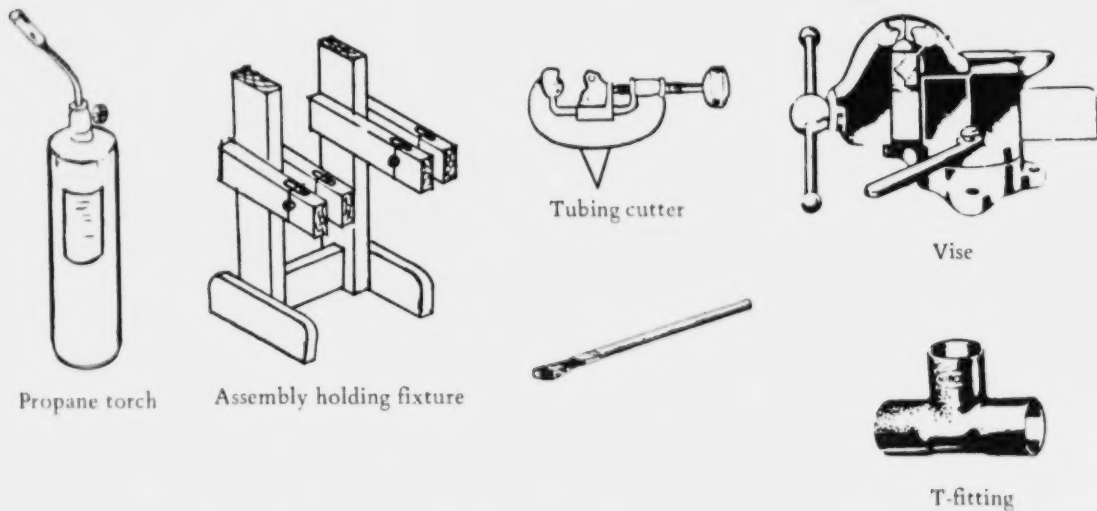


Figure 10

You will need the following equipment and materials:

flux
solid core 50/50 wire solder

1. Get a piece of copper pipe and fasten about 4" of one end in a vise.
2. Mark six inches from the other end with a pencil.
3. Use a tubing cutter or a pipe cutter to cut the pipe off at the 6" mark.
 - A. Open the cutting tool and place the cutter wheel on the 6" mark.

- B. Close the cutter by tightening the knob handle clockwise (see Figure 11).

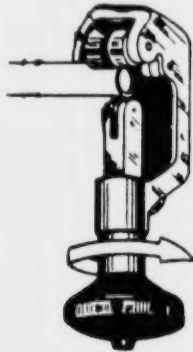


Figure 11

- C. Rotate the cutter one turn to make sure that it is aligned properly. (**Note:** If the cutter wheel makes a double line, you must reposition the cutter.)
- D. Tighten the handle an extra quarter turn clockwise.
- E. Rotate the cutter at least one full turn and tighten the knob another quarter turn (see Figure 12).
- F. Repeat Step E (previous step) until the pipe separates.



Figure 12

4. Remove the burr on both pieces using the reamer on the tubing cutter. Insert the reamer in the pipe and twist it all the way around using a little pressure (see Figure 13).



Figure 13

5. Use steel wool to clean both the end of the pipe (see Figure 14) *and* the inside of the fitting that it will join (see Figure 15).

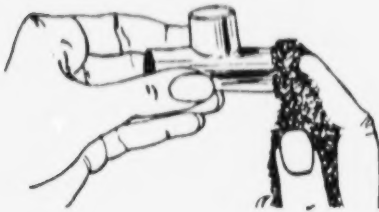


Figure 14

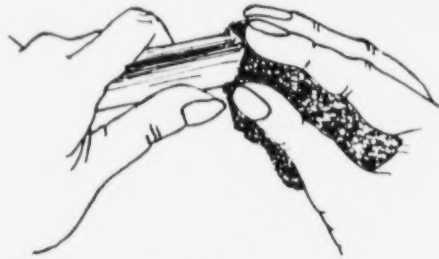


Figure 15

6. Use a flux brush to coat the end of the pipe and the inside of the fitting with non-corrosive flux (see Figure 16). Rotate the pipe in the fitting to spread the flux evenly.

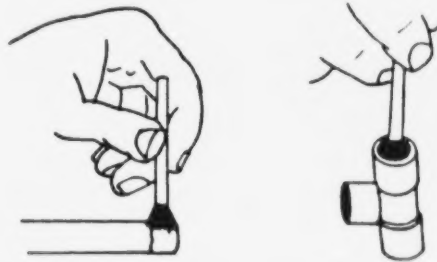


Figure 16

7. Light the propane torch with a spark igniter and adjust the flame.

► Caution

The propane torch should be used only with your instructor's permission and/or presence.

A fire extinguisher should be nearby when open flames are used.

8. Apply heat to the fitting only. (**Note:** Do not apply heat to the pipe or to the solder.) When the flux bubbles or begins to smoke, go to Step 9.

9. Apply 50/50 solder to the opening of the fitting (see Figure 17). Run the solder wire around the fitting joint quickly.

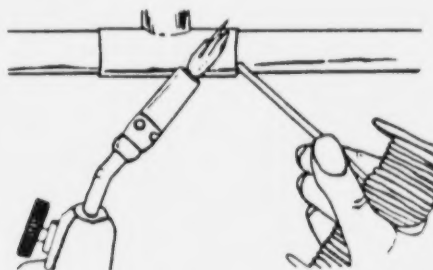


Figure 17

10. When the first drop of solder falls out of the fitting, the joint is finished.
11. Repeat Steps 8 and 9 for the other joint.
12. While the solder is still molten, wipe each joint with a rag.

How It Works

If you performed your soldering operation properly, you probably noticed that the molten solder was sucked into the fitting. This phenomenon is called capillary attraction. Your science teacher or your librarian can help you find out more about capillary attraction. For now, it is important for you to know that the molten solder will follow the heat. This is why you only heat the fitting. Heat from the fitting is conducted to the pipe so that the pipe becomes hot enough to melt the solder. The melted solder then follows the heat, drawing it into the fitting. When you first put the pipe and the fitting together, it may have seemed that there was not space between them. Actually the fitting was designed so that there would be a small, but definite space between the walls of the fitting and the pipe. It was this space that the molten solder flowed into to create a sealed joint (see Figure 18).

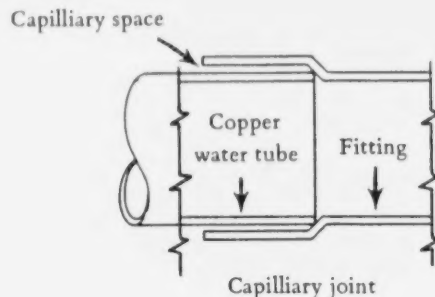


Figure 18

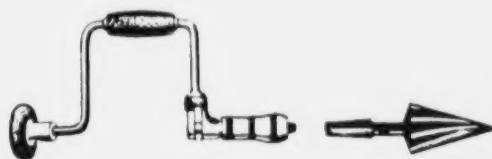
Solvent Welding Plastic Pipe

More and more new homes today are using plastic piping systems for the distribution of fresh water. Plastic pipe is also replacing cast iron for waste water systems. In this activity, you will be using polyvinyl chloride (PVC) pipe to assemble a simple T-fitting joint. Joining plastic pipe is the simplest of all plumbing processes, but there are secrets to success, so read on carefully.

Tools



Hack saw



Brace and reamer bit



Sloyd knife

Figure 19

You will need the following equipment and materials:

- 12" of 1/2" PVC pipe
- pipe fitting
- pipe cleaner
- PVC joint solvent
- fine-grit abrasive paper or cloth
- solvent brush

1. Place the pipe in a vise and make a pencil mark 4" and 8" from one end.
2. Cut pipe off square with either a hacksaw or a tubing cutter (see Figure 20).

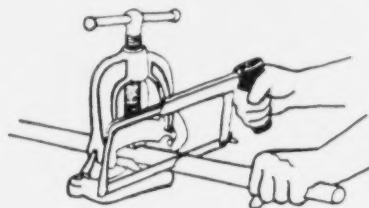


Figure 20

3. Remove the burrs and ridge (see Figure 21) from the outside and inside with a knife, file, and/or reamer.

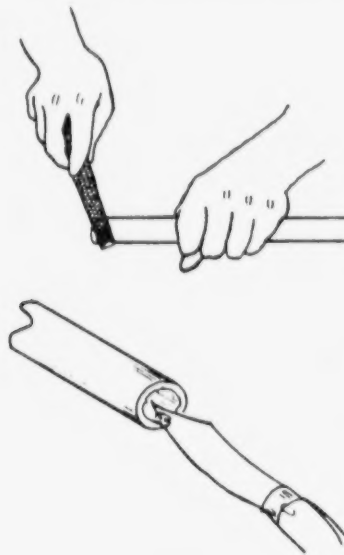


Figure 21

4. Check the fit. The pipe should slide into the fitting smoothly.
5. Make a pencil mark on both parts to aid in alignment later (see Figure 22).

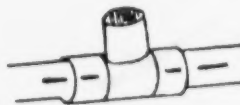


Figure 22

6. Remove the gloss from the end of the pipe and the inside of the fitting with PVC cleaner. Read the directions on the can. (Note: Sandpaper can be used, but wipe the parts clean with a dry rag afterward.)
7. Brush cement on the end of the pipe and the inside of the fitting (see Figure 23). (Note: Do not dip the parts into the cement.)



Figure 23

8. Push the pipe into the fitting. Twist the fitting a quarter turn to distribute the cement evenly.
9. Twist the T-fitting so that the alignment marks from Step 5 line up.
10. Hold unit firmly until cement sets.
11. Wipe excess cement off the fitting lip with a rag.
12. Repeat Steps 7 to 11 for the other two branches of the fitting.

Laundry Sink Installation

You will work in pairs to assemble the required plumbing for a laundry sink.

Tools

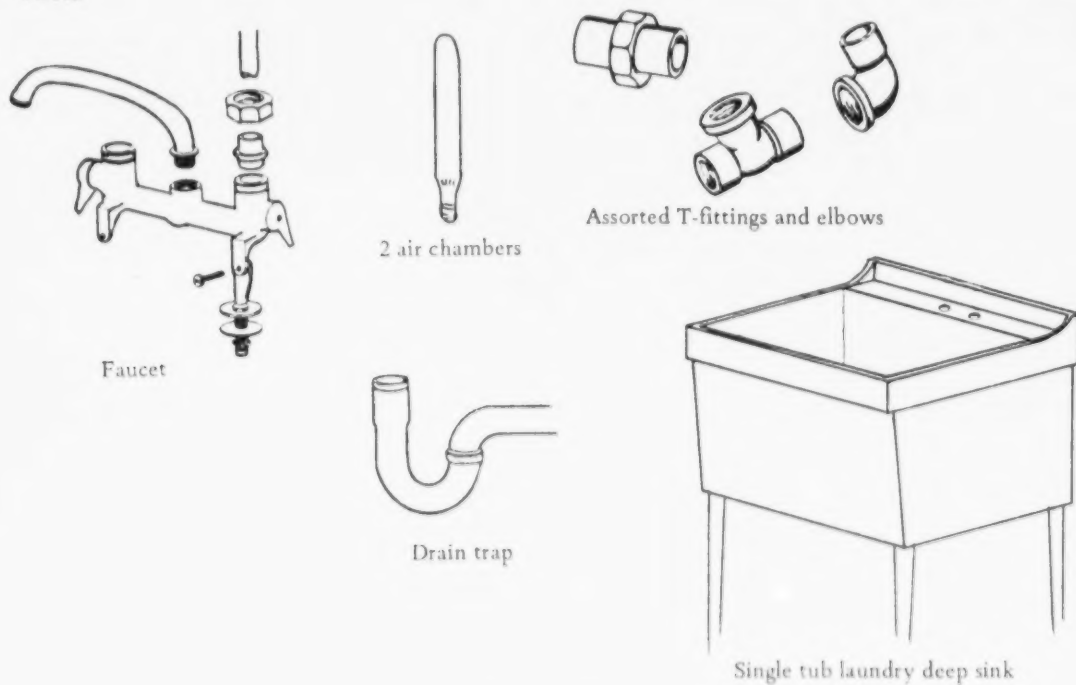


Figure 24

You will need the following equipment and materials:

- pipe wrench
- screwdriver
- assorted lengths of PVC pipe (1/2" and 1-1/2")

1. Go to the wall section module and study the plans for the sink installation (see Figures 25 and 26).
 - A. Decide, along with your partner, who is going to be the plumber and who is going to be the apprentice.
 - B. Check the pipe and fittings inventory to become familiar with all parts.
 - C. Notice that the water lines and the sewer lines are already installed. You will be installing the sink to the supply and discharge lines.
2. Place the laundry sink in place and fasten with screws.
3. Install laundry faucet on the sink.
4. Measure for the lengths of pipe required to connect the hot water line and select the proper pieces of pipe.
5. Assemble the hot water line *without cement* and attach it to the supply pipe and the proper faucet.
6. Repeat Steps 4 and 5 for the cold water line.
7. Install the air chambers.
8. Measure for and select parts necessary to connect the drain and vent line.
9. Assemble the drainage line and vent stack in their proper locations, according to the plan.
10. Have your instructor check your work.
11. Disassemble the plumbing module parts that you installed and return them to their designated places.

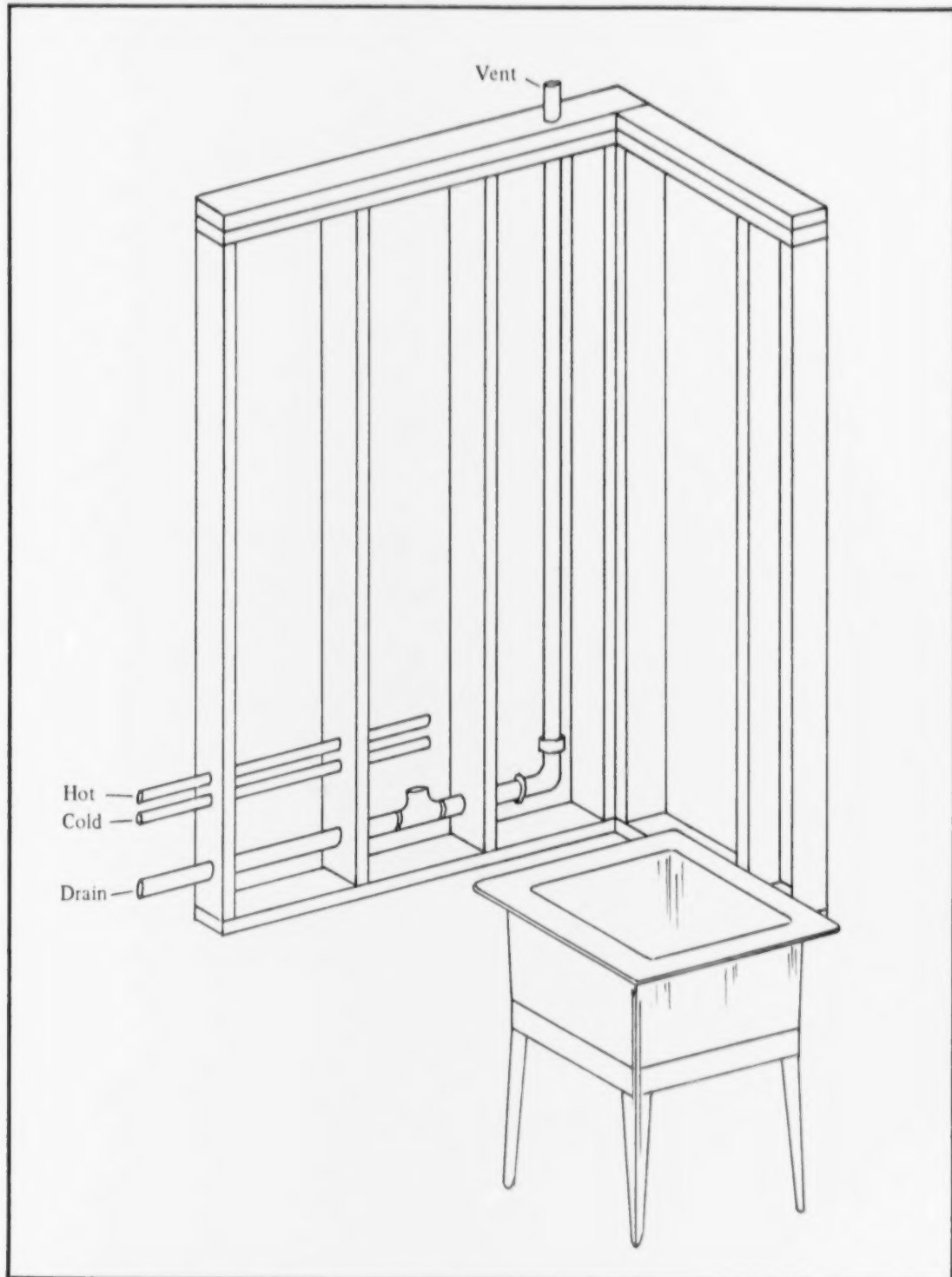


Figure 25

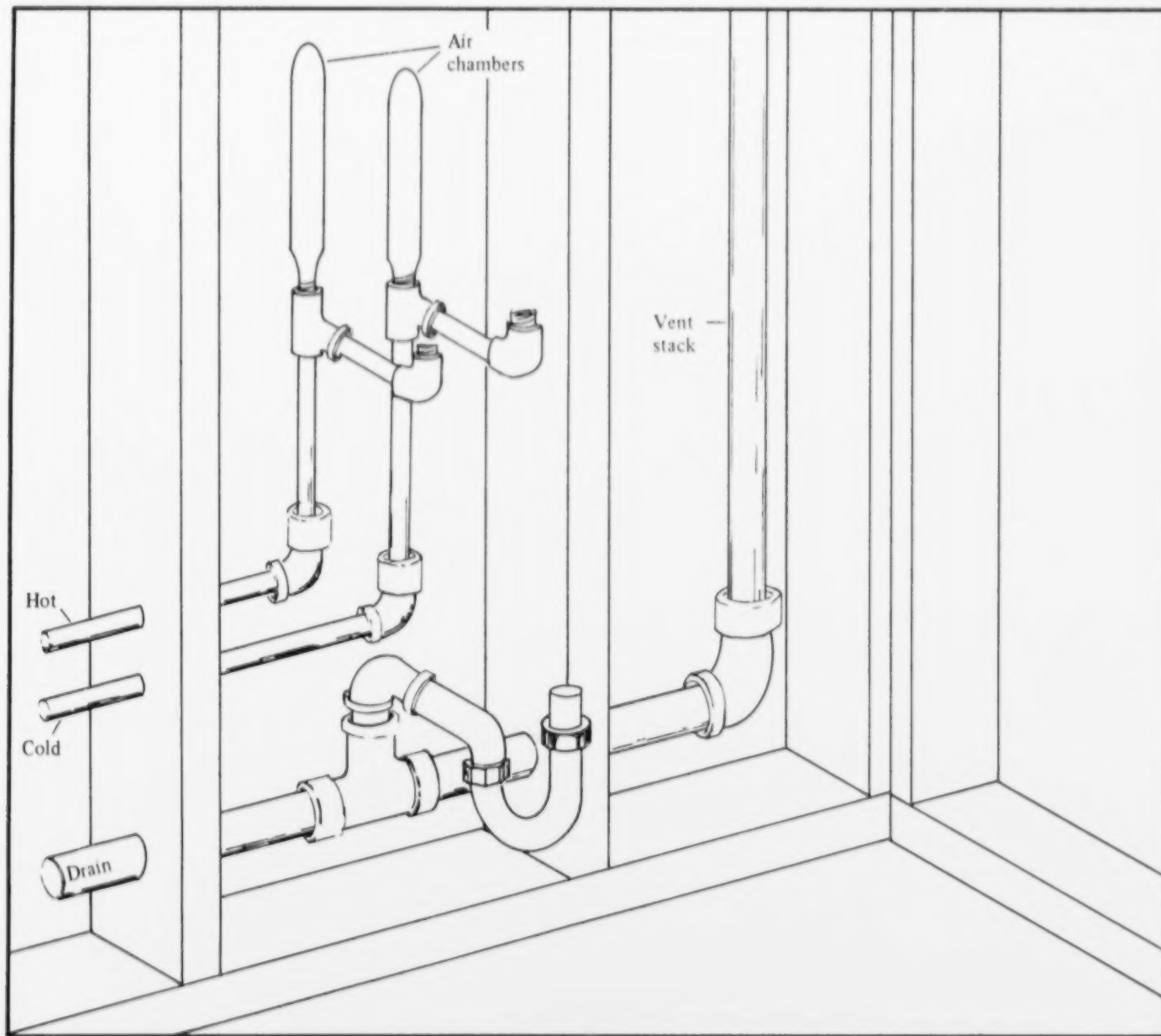


Figure 26

(2C) Installing Utility Systems

Construction

Wiring Duplex Outlets, an activity supporting the Construction Production Processes concept, is designed for approximately 2 class periods.

Resources Needed

Materials

- 3 rectangle outlet boxes, standard size
- 1 single-pole switch, standard size
- 2 duplex receptacles, standard size
- Nonmetallic sheathed cables (Romex), 14-2
- Solderless connectors (wire nuts)

Suggested References

- Hunter, Richard. *Electrical House Wiring Explained*. Garden City, NY: Bergwall Productions, Inc., 1977.
- Mix, Floyd M. *House Wiring Simplified*. South Holland, IL: Goodheart-Wilcox Co., Inc., 1973.

Objectives

The student will

- correctly wire and install a duplex receptacle;
- correctly wire and install a switch to control power to a duplex receptacle; and
- correctly ground the circuit.

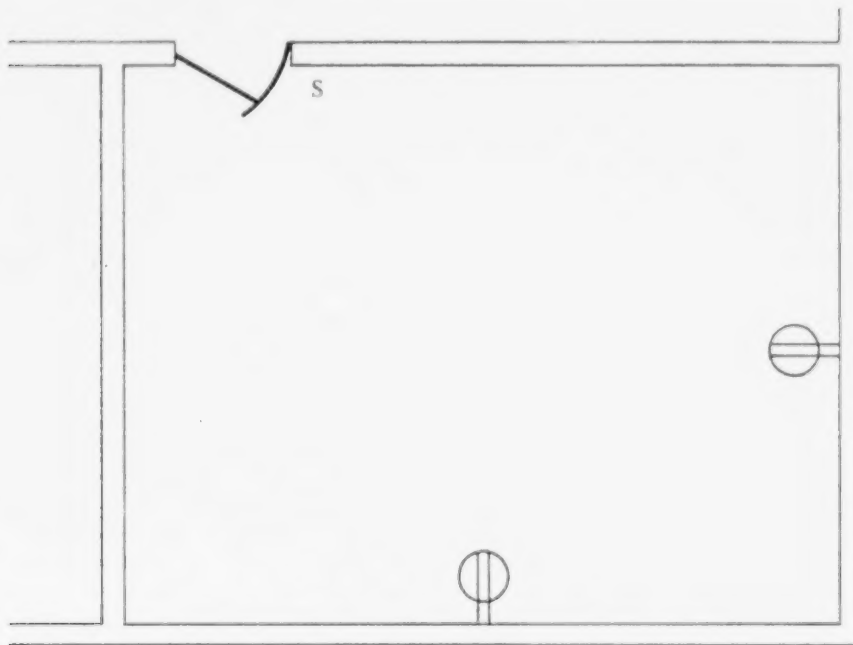
Evaluation Focus

- | | | |
|---|--|-----------------------------------|
| ☒ Knowledge | ☐ Problem Solving | ☐ Attitude |
| ☐ Awareness | ☒ Machine/Tool Usage | |

Wiring Duplex Outlets

Procedure

This activity is intended to help you understand and correctly wire duplex outlet receptacles. Be sure to study the drawing so that you know *what* you are supposed to do. Be sure to study the procedures so that you know *how* you are supposed to do it.



1. Select the tools you will need.
2. Select the components and wire or cable you will need.
3. Run the wire to the boxes you intend to use.
4. Secure the wire in the boxes. Make sure you leave 6" to 8" of wire extending from the box.
5. Strip the outer covering from the wire to within 1" of the cable clamp on the box.
6. Ask the instructor to check your progress and initial this step.

7. Strip and form open terminal loops on all wire ends.
8. Connect the wires to the switch and receptacles.
9. Check to make sure that
 - you have observed correct polarity;
 - your terminal connections and wire nuts are tight; and
 - the circuit is correctly grounded.
10. **Ask the instructor to check your progress and initial this step.**
11. Install the switch and light fixture in the boxes. (**Note:** Be careful not to pinch any wires or short any terminals to ground.)
12. **Ask the instructor to help you check the circuit's operation. If circuit is approved, go on to Step 13. If not, go back to Step 8.**
13. Carefully remove the switch and light fixture from the boxes and disconnect the wires.
14. Cut the open terminal loops off the ends of the wire and remove the wire from the boxes.
15. Put all the tools and materials back in the correct cabinets and storage bins.

(2C) Installing Utility Systems

Construction

Wiring Light Fixtures, an activity supporting the Construction Production Processes concept, is designed for approximately 2 class periods.

Resources Needed

Materials

- 1 octagon box, standard size
- 1 rectangular outlet box, standard size
- 1 single-pole switch, standard size
- 1 ceramic keyless light fixture, standard size
- Nonmetallic sheathed cable (Romex), 14-2
- Solderless connectors (wire nuts)

Suggested References

- Hunter, Richard. *Electrical House Wiring Explained*. Garden City, NY: Bergwall Productions, Inc., 1977.
- Mix, Floyd M. *House Wiring Simplified*. South Holland, IL: Goodheart-Wilcox Co., Inc., 1973.

Objectives

The student will

- correctly wire and install a light fixture;
- correctly wire and install a switch to control the light when the switch is beyond the light; and
- correctly ground the circuit.

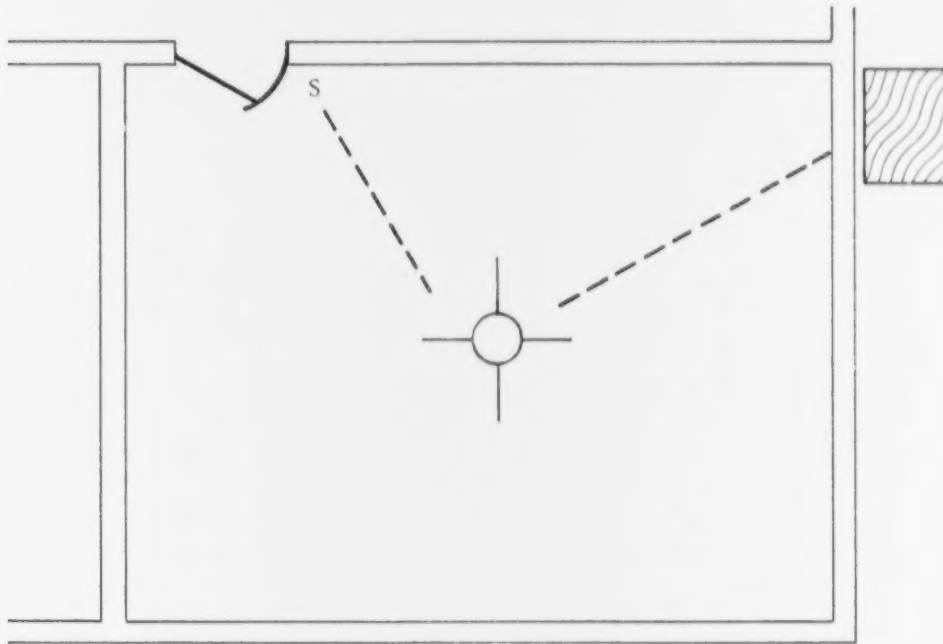
Evaluation Focus

- | | | |
|---|--|-----------------------------------|
| ☒ Knowledge | ☐ Problem Solving | ☐ Attitude |
| ☐ Awareness | ☒ Machine/Tool Usage | |

Wiring Light Fixtures

Procedure

This activity is intended to help you understand and correctly wire a light fixture when the switch is beyond the light. Be sure to study the drawing so that you know *what* you are supposed to do. Be sure to study the procedures so that you know *how* you are supposed to do it.



1. Select the tools you will need.
2. Select the components and wire or cable you will need.
3. Run the wire to the boxes you intend to use.
4. Secure the wire in the boxes. Make sure you leave 6" to 8" of wire extending from the box.
5. Strip the outer covering from the wire to within 1" of the cable clamp on the box.
6. Strip and form open terminal loops on the wire ends that will be connected to the terminals on the switch or light fixture only. *Do not* form terminal loops on the wires that will be connected with wire nuts.
7. Ask the instructor to check your progress and initial this step.

8. Connect the black feed wire to the white wire that goes to the switch with a wire nut.
Note: When using Romex in this situation *only*, you will have to connect a black wire to a white wire. This is done so that the black wire coming from the switch will be "hot." Wiring switches with Romex is the *only* time you *ever* connect a black wire to a white wire, and the white wire must be tagged or colored black so that it will not be mistaken for a neutral wire.
9. Connect the wires to the switch and the light fixture, and ground the circuit.
10. Check to make sure that
 - you have observed correct polarity;
 - your terminal connections and wire nuts are tight; and
 - the circuit is correctly grounded.
11. **Ask the instructor to check your progress and initial this step.**
12. Install the switch and light fixture in the boxes. (**Note:** Be careful not to pinch any wires or short any terminals to ground.)
13. **Ask the instructor to help you check the circuit's operation. If circuit is approved, go on to Step 14. If not, go back to Step 8.**
14. Carefully remove the switch and light fixture from the boxes and disconnect the wires.
15. Cut the open terminal loops off the ends of the wire and remove the wire from the boxes.
16. Put all the tools and materials back in the correct cabinets and storage bins.

(2C) Installing Utility Systems

Construction

Wiring Three-Way Switches, an activity supporting the Construction Production Processes concept, is designed for approximately 2 class periods.

Resources Needed

Materials

- 1 octagon box, standard size
- 2 rectangular outlet boxes, standard size
- 2 three-way switches, standard size
- 1 ceramic keyless light fixture, standard size
- Nonmetallic sheathed cable (Romex), 14-2
- Nonmetallic sheathed cable (Romex), 14-3
- Solderless connectors (wire nuts)

Suggested References

- Hunter, Richard. *Electrical House Wiring Explained*. Garden City, NY: Bergwall Productions, Inc., 1977.
- Mix, Floyd M. *House Wiring Simplified*. South Holland, IL: Goodheart-Wilcox Co., Inc., 1973.

Objectives

The student will

- correctly wire and install a light fixture which is turned on and off (controlled) by two three-way switches; and
- correctly ground the circuit.

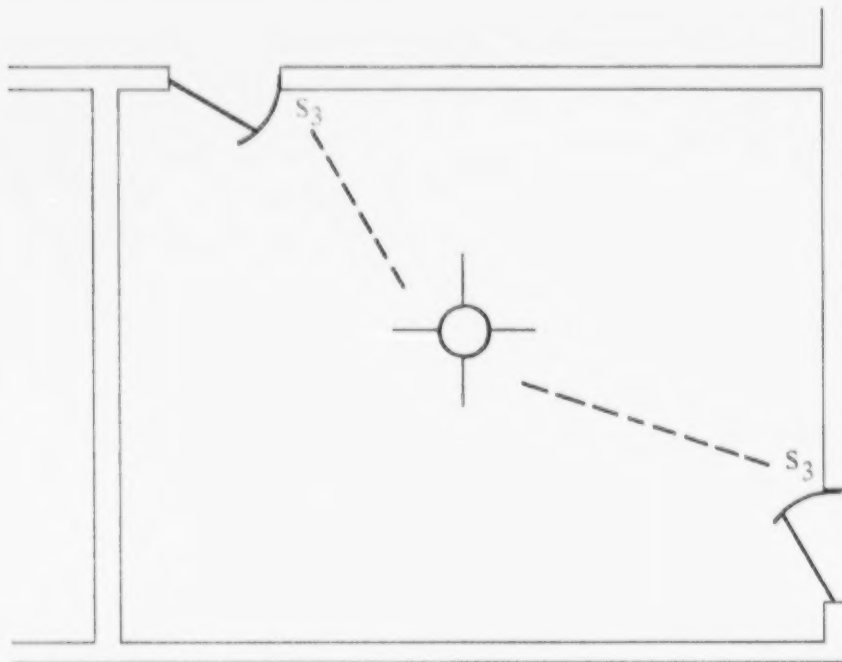
Evaluation Focus

- | | | |
|---|--|-----------------------------------|
| ☒ Knowledge | ☐ Problem Solving | ☐ Attitude |
| ☐ Awareness | ☒ Machine/Tool Usage | |

Wiring Three-Way Switches

Procedure

This activity is intended to help you understand and correctly wire three-way switches. Using two three-way switches allows control of a light from two locations. Be sure to study the drawing so that you know *what* you are supposed to do. Be sure to study the procedures so that you know *how* you are supposed to do it.



1. Select the tools you will need.
2. Select the components and wire or cable you will need.
3. Run the wire to the boxes you intend to use.
4. Secure the wire in the boxes. Make sure you leave 6" to 8" of wire extending from the box.
5. Strip the outer covering from the wire to within 1" of the cable clamp on the box.
6. Strip and form open terminal loops on the wire ends that will be connected to the terminals on the switch or light fixture only. *Do not* form terminal loops on the wires that will be connected with wire nuts.

7. Check the following on your wiring so far. Make sure that
 - the feed wire is 14-2 cable and goes to a switch box; and
 - you have used 14-3 cable between the switch boxes and the octagon box.
8. **Ask the instructor to check your progress and initial this step.**
9. Strip the ends of the wires.
10. Determine which wires will be connected to terminals and which wires will be connected together with wire nuts.
 - A. The black (hot) feed wire will connect to the common terminal (darker color) of the first switch.
 - B. The two white wires will be connected together. This is because the white wire between the first switch and the light is the neutral wire.
 - C. The black and red wires of the 14-3 cable will be the runners. They are connected to the lighter colored terminals on both switches.
 - D. The white wire coming from the second switch will be hot. It should be tagged or colored black so it will not be confused with the neutral wire.
11. Form open terminal loops on the wires that will be connected to the terminals.
12. Connect each wire to the correct terminal or wire, and ground the circuit.
13. Check to make sure that
 - you have observed correct polarity;
 - your terminal connections and wire nuts are tight; and
 - the circuit is correctly grounded.
14. **Ask the instructor to check your progress and initial this step.**
15. Install the switches and light fixture in the boxes. (**Note:** Be careful not to pinch any wires or short any terminals to ground.)
16. **Ask the instructor to help you check the circuit's operation. If circuit is approved, go on to Step 17. If not, go back to Step 10.**
17. Carefully remove the switches and light fixtures from the boxes and disconnect the wires.
18. Cut the open terminal loops off the ends of the wire and remove the wire from the boxes.
19. Put all the tools and materials back in the correct cabinets and storage bins.

(2G) Servicing the Project

Construction

Home Energy Monitoring, an activity supporting the Construction Production Processes concept, is designed for approximately 4 class periods.

Resources Needed

Suggested References

Sears, George. "25 Heat Leaks and How to Plug Them." *Popular Science* (Feb. 1984), p. 97.

Wing, Charles. *House Warming*. Boston, MA: Little, Brown Co., 1983.

Objectives

The student will

locate and identify a gas and electric meter;
conduct an audit (examination or review) of the amount of energy used;
and
make recommendations as to how energy can be saved.

Evaluation Focus

- ☒ Knowledge
- ☒ Awareness

- ☒ Problem Solving
- ☒ Machine/Tool Usage

- ☐ Attitude

Home Energy Monitoring

Procedure

Nearly all the energy used today comes from fossil fuels—a nonrenewable resource that is being rapidly consumed. There are differing opinions as to the amount of fossil fuels remaining in the earth, but one thing is certain. When the present supply is gone, there will be no more. This is a good argument for energy conservation.

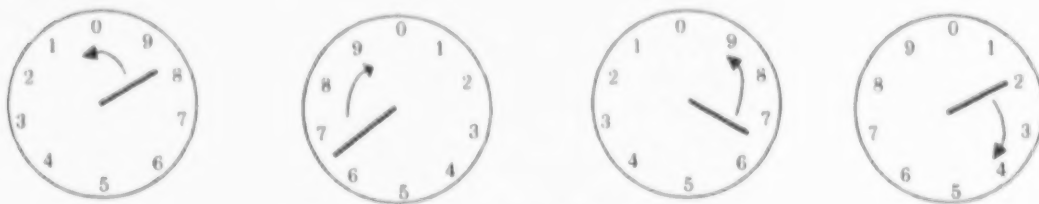
We know that energy can be conserved. Much of what we use currently is wasted. It has been estimated that the use of energy can be reduced by 30 percent without creating hardships on anyone. This conservation of energy can start in the home.

Do you know how much electricity or gas is used in your home? You can learn how to read your electric meter and gas meter. These meters tell how much electricity and/or natural gas is used in your home. This activity will show you how to measure the amount of energy being used in your household and also will have you consider ways your family can reduce the amount of energy used.

How to Read Your Electric Meter

In order to know how much electrical energy is being used, you will have to read the electric meter each week. Electric meters measure the amount of electricity used, expressed in a unit called "kilowatt hours." A kilowatt hour (KWH) is 1,000 watts of electricity flowing for one hour. Each kilowatt hour of electricity will cost a specified amount. This is stated on the bill from the electric company.

Electric meters have either four or five dials. To read the dials, first note the direction each dial arrow moves. Notice that the dial pointers may move in different directions, but they always move toward the larger number on the dial. Read the number at the end of each pointer. **Note:** If the pointer is between numbers, read the smaller number.



The above meter dials read 86,620 KWH.

If the meter has four dials, multiply the reading by ten (add a zero).



Reading = 65,482 KWH

A five-dial meter is read directly. (Do not multiply by ten.)

1. Practice meter reading by being certain you understand these examples.



Reading = 66,190 KWH



Reading = 35,721 KWH

2. On the "Electric Meter Reading" section of the Student Response Sheet, read the three meters and place your answers in the spaces provided.
3. This part of your activity will have to be completed at home. To determine how many KWH's of electricity your household uses in one day, it is necessary to make two meter readings, approximately 24 hours apart, and record the difference between them.

Example: Figuring electricity used in a 24-hour period.



Monday afternoon meter reading = 13,478 (first reading)



Tuesday afternoon meter reading = 13,488 (second reading)

To figure how much electricity was used in one day, subtract the first reading from the second reading. This will give you the number of kilowatt hours of electricity used.

$$\begin{array}{r}
 13,488 \text{ (second reading)} \\
 - 13,478 \text{ (first reading)} \\
 \hline
 10 \text{ KWH used in one day}
 \end{array}$$

Figure how much electricity was used in your household in one day by making two meter readings approximately 24 hours apart. Record your meter readings on the "24-Hour Electric Meter Reading" section of the Student Response Sheet.

Other Types of Energy Used in the Home

To make a check of the total amount of energy used in your household, you will also have to record the amount of fuel oil used (if any) or natural gas used for heating (if any). If your home is a "total electric home," the amount of electricity used will be the total energy used.

1. **Natural Gas Meters**—Gas meters are read in the same way as electric meters, except they measure in thousand cubic feet of gas. You must therefore multiply gas meter readings by 1,000 (add 3 zeros to the reading).

Make two meter readings over a 24-hour period to find out how many cubic feet of natural gas your household uses. Record your data on the "24-Hour Natural Gas Meter Reading" section of the Student Response Sheet.

2. **Fuel Oil (if appropriate)**—If your household uses fuel oil for heating, it will be difficult to get an accurate record of the amount of fuel oil used each day, or even each month. Fuel oil is usually delivered by truck in large amounts, usually only a couple of times a year. If you can obtain the bills for the oil for the past year, you can figure the average amount of oil used each month or each day during the heating season. Follow the steps on the "Fuel Oil" section of the Student Response Sheet. (The heating season will vary in various parts of the country. In warmer climates, it may be only two or three months. In cold climates, it may extend for six or seven months. The difference in weather from year to year will also have an effect on the amount of fuel used for heating.)

Electrical Energy Used by Household Appliances

As part of your home energy monitoring, you can *estimate* the energy consumed by household appliances. This will give you some idea of how your family used all the watts of electricity that you recorded earlier.

Keep in mind that, at best, these figures are only estimates. Appliances differ in amounts of electricity used, even when they are made by the same manufacturer. Different models may consume more or less electricity. The energy consumed by an appliance also can vary from season to season. A refrigerator, for example, will run longer and more often in hot weather than in cooler weather.

Although these figures may be inaccurate, they can help you become more aware of the energy consumed by different appliances. From this you should be able to make better informed choices or decisions when using or buying appliances. We also can hope that as people become more energy conscious, more energy-saving appliances will be developed.

This chart lists the annual energy requirements of electric household appliances. Both the average wattage and the estimated KWH consumed annually by each appliance is given.

The estimated annual KWH consumption of the electric appliances listed here is based on normal usage. When using these figures for projections, such factors as the size of the specific appliance, the geographical area of use, and individual usage should be taken into consideration. (Data supplied by Edison Electric Institute.)

Appliance	Average Watts Hr.	Est. KWH Consumed Annually
Air conditioner (room)	860	860
Broiler	1,140	85
Clothes dryer	4,856	993
Coffee maker	1,200	140
Dehumidifier	257	377
Dishwasher	1,201	363
Fan (circulating)	88	43
Floor polisher	305	15
Frying pan	1,196	100
Furnace fan	500	650
Hair dryer	600	25
Heater (portable)	1,322	176
Hot plate	1,200	90
Humidifier	177	163
Mixer	127	2
Oven, microwave (only)	1,450	190
Radio	71	86
Radio/record player	109	109
Range with oven	12,200	700
with self cleaning oven	12,200	730
Refrigerator/freezer, manual defrost, 12.5 cu. ft.	-	1,500
automatic defrost, 17.5 cu. ft.	-	2,250
Roaster	1,333	60
Sewing machine	75	11
Shaver	15	0.5
Sun lamp	279	16
Television, black and white, tube type	100	220
black and white, solid state	45	100
color, tube type	240	528
color, solid state	145	320
Toaster	1,146	39
Vacuum cleaner	630	46
Washing machine (automatic)	512	103
Washing machine (nonautomatic)	286	76
Water heater	2,475	4,219
quick recovery	4,474	4,811

1. On the "Estimated Electricity Usage" section of the Student Response Sheet, list as many appliances as possible that were used in your household between your first and second electric meter readings.
2. On the usage chart, list the watts per hour each appliance uses. (This information can be acquired in one of two ways. You can look up the average watts per hour used by the appliance on the chart given earlier, or for a more accurate figure, you can find this information on the appliance's identification tag (usually located on the back of the appliance).
3. *Estimate* the amount of time each appliance was used during the 24-hour period between your two meter readings. Write the estimated time in the chart under "Estimated Use."
4. Figure out the amount of electricity used by each appliance by multiplying its watts per hour by the amount of time the appliance was used (watts/hr. x time = watts of electricity used).
5. Add the wattage used by all the appliances. (Add the numbers in the "watts" column of the chart. Place the total below this column.) Your answer should be close to the number obtained from your meter reading (plus or minus 500 watts).

Air Leaks

1. There are other ways to save energy in the home. It has been estimated that 30 percent of all energy is wasted because of "air leaks." Air leaks are defined as places where cold air can leak into your house or where hot air can leak out. Using the "Air Leaks" section of the Student Response Sheet as a guide, check for air leaks in your own home or apartment. List the air leaks that you find on the chart provided.
2. Identify materials or methods you might use to seal each leak, and list them on the chart.

Home Energy Monitoring

Name _____

Class/Period _____

Electric Meter Reading

Place a number below each dial to record what the dial is reading. Also place the complete reading in the space provided to the left. Indicate with an arrow which way the pointer is moving on each dial.











Complete meter reading _____











Complete meter reading _____







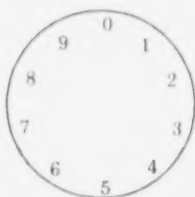


Complete meter reading _____

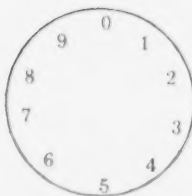
24-Hour Electric Meter Reading

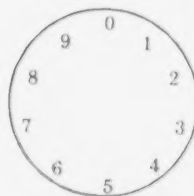
Record your data below.



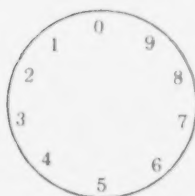


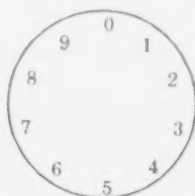


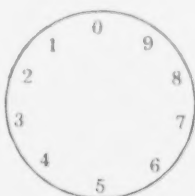


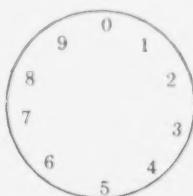


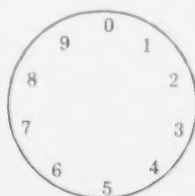
First meter reading











Second meter reading

(Taken approximately 24 hours after the first reading)

How many kilowatt hours of electricity did your household use in 24 hours?

Approximately how much did it cost? (Note: Check your electric bill for cost per KWH.)

24-Hour Natural Gas Meter Reading

Record your data below.



First meter reading
(Remember that natural gas is
measured in thousands of cubic
feet used.)



Second meter reading

How many thousands of cubic feet of natural gas did your household use in 24 hours?

Approximately how much did it cost? (**Note:** Check your gas bill for cost per 1,000 cubic feet.)

Fuel Oil
(If Appropriate)

Figure the average amount of fuel oil used during one month (during the heating season).

_____ (yearly bill) ÷ 6 (months in heating season) = _____
Average amount of fuel oil used
(in gallons)

Figure the average amount of fuel oil used in one day.

$$\frac{\text{_____ (above answer)} \div 30 \text{ (avg. days in a month)}}{\text{Average amount of fuel oil used in one day (in gallons)}}$$

How much does one gallon of fuel oil cost? _____
(Note: Check your fuel oil bill for cost figure.)

Air Leaks

Check for Leaks in These Areas	Suggested Sealing Materials to Use	Comments
Attic door (or scuttle) Baseboards Basement door Basement windows Chimney Clothes dryer vent Electric service cable Fireplace Fireplace clean-out door Furnace flue Heating ducts Medicine cabinet Outlets and switches Outside door Outside faucet Plumbing vents Recessed light fixture Room air conditioner Sill plate Telephone cable TV antenna or cable entrance Ventilation fan Wall-mounted electrical fixtures Windows		

Estimated Electricity Usage

Appliance	Watts per Hour	Estimated Use (in Hours)	Watts (of Electricity Used)
Total Watts Used ►			

Is this number close to the number from your meter readings (plus or minus 500 watts)?

(3A) Planning

Construction

Testing Insulation Material, an activity supporting the Construction Managerial Processes concept, is designed for approximately 2 to 3 class periods.

Resources Needed

Equipment

Insulation test boxes (one cubic foot frames covered with insulation samples)
Indoor/outdoor thermometers
Light fixtures with 100-watt bulbs

Material

Graph paper and colored pens/pencils

Option

Students can build the insulation test boxes from 12' of 2" x 2" wood for each box needed.

Suggested Reference

Wing, Charles. "The Theory of Insulation." In *House Warming*. Boston, MA: Little, Brown and Co., 1983.

Objectives

The student will

explain what insulation does;
identify various types of insulation materials;
test R-values of various insulating materials;
graph a time/heat rise chart of several different materials; and
identify which materials have better insulating ability (R-value).

Evaluation Focus

☒ Knowledge
☐ Awareness

☒ Problem Solving
☐ Machine/Tool Usage

☐ Attitude

Testing Insulation Material

Introduction

In this activity, you will learn about various kinds of insulation material and how it can be tested. By plotting test results on a graph, you will be able to reach some conclusions about the effectiveness of the different kinds of insulation. Begin by familiarizing yourself with the language that is used to talk about insulation.

Terminology

Heat—energy that is needed to cause temperature to rise.

Heat loss—the loss of such energy.

BTU (British Thermal Unit)—the amount of heat necessary to raise the temperature of one pound of water one degree Fahrenheit. One cubic foot of natural gas contains 1,000 BTU's, for example.

Degree days—a measurement of the number of degrees the average temperature deviates from 65 degrees each day during the heating season. For example, if on December 15 the average outdoor temperature was 15 degrees, then 65 degrees minus 15 degrees equals 50 degree days for that particular day. (There are approximately 8,000 degree days per year in the Wisconsin Power and Light service area.)

Infiltration—air flowing into a home through cracks, fireplaces, and fans or between windows and frames or doors and frames.

R-value—the measurement of the ability of a material to resist the flow of heat. The higher the R-value the greater resistance to heat loss. Insulation material with an R-value of 22 has twice the insulation value of material with an R-value of 11.

Vapor barrier—a material which retards the movement of water vapor through the walls, ceilings, and floors of a building.

How to Determine R-Value

Insulation is manufactured in many forms and by a number of different companies. Therefore, the R-value may not be the same for all insulation. *Batt* or *blanket* insulation 10" thick will have a different R-value than 10" of *loose fill* insulation.

To determine the R-value of any particular insulation, first measure the amount of insulation being used, in inches. Then, using a chart, multiply the number of inches of insulation by the R-value of the particular type of insulation.

For example, if you have 5" of cellulose, its total R-value would be R18.5 (5" x 3.7).

<u>Insulation</u>	<u>R-Value Per Inch</u>
Loose Fill	
fiberglass	3.3
mineral wool	3.3
rock wool	3.3
vermiculite	2.1
cellulose	3.7
Rigid	
expanded polystyrene	5.0
expanded polystyrene, molded beads	3.6
expanded polyurethane	6.3

Blanket or batts of fiberglass, mineral wool, and rock wool come in standard widths.

<u>Width</u>	<u>R-Value</u>
3-1/2"	R11
3-5/8"	R13
6"	R19
9"	R30

Procedure

1. Look at the insulated test boxes and decide which should be the most effective. (You'll need to know the type of insulation being used in the box and its thickness.) Next you will actually test the insulation, so you can compare your estimate with your actual results.
2. Record the temperature increase inside one of the insulated test boxes. To do this:
 - A. Place a light fixture on the table.
 - B. Get an insulated test box, slip the thermometer probe inside, and fasten with tape. You will be able to read the temperature from outside the box.
 - C. Place the insulation box over the lamp. (Lamp should be off.)
 - D. Get paper and pencil to record minutes and temperature.

Example:	<u>Minutes</u>	<u>Temperature</u>
	0	72
	1	75
	2	80

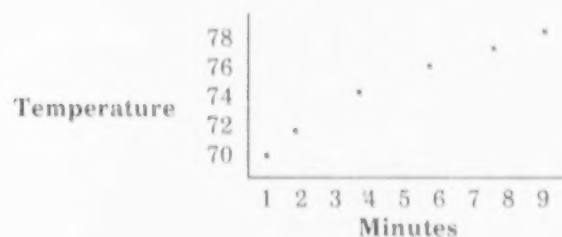
E. Turn on the lamp, and record the temperature increase until it stops going up.

► **Caution**

Do not touch the 100-watt bulbs with your bare hands.
They will be hot enough to cause burns.

3. Continue recording data from the next box until all boxes have been tested.
4. Graph the temperature rise over time using different colors for each type of insulation.

Example:



5. Compare the graphs for each of the insulating test boxes. You should be able to determine what kind of insulation has the best R-value.
6. Write a report of your conclusions.

(3A) Planning

Construction

Understanding Flowcharts, an activity supporting the Construction Managerial Processes concept, is designed for approximately 1 class period.

Resources Needed

None

Objectives

The student will

consider the importance of water to human life;
learn how to interpret a flowchart; and
design a flowchart to depict a given set of circumstances.

Evaluation Focus

- | | | |
|------------------------------------|---|--|
| ☐ Knowledge | ☒ Problem Solving | ☒ Attitude |
| ☐ Awareness | ☐ Machine/Tool Usage | |

Understanding Flowcharts

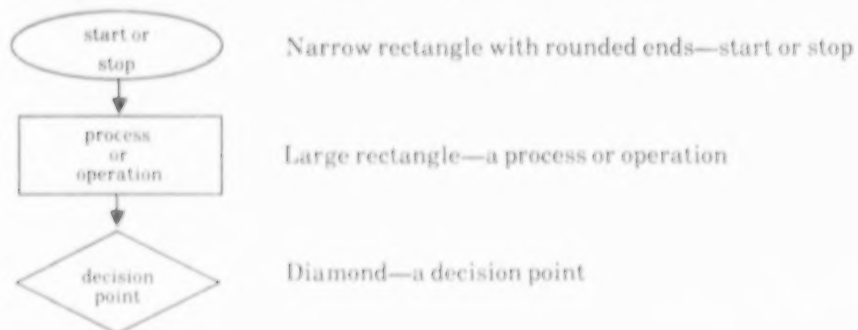
Procedure

1. In this activity, students are cast either individually or in pairs as hydraulic (water) system engineers who are examining a municipal water system. Begin with a short introduction of the historical significance of a good water supply and its effects on our choice of living places. Preparation for the activity includes a brief review of printed instructions and graphic material and a "chalk talk" on flowchart symbols. The student's first task is to read a short paragraph that describes elements and operations of a city's water system. The second task is to draw a diagram that depicts both the elements and their functional relationship. A skeletal flowchart is provided, but the student is free to make an original drawing. The completed products are presented before the class and discussed. Finally, lead the class through one typically correct solution, and conclude with a review of the skills that were employed in the activity. These include following oral and printed instructions, reading for specific content, and drawing a logical flowchart.
2. Start the activity by asking students what they believe was *the* most important factor that determined where early people settled. Tell the students to think in terms of basic needs. Lead the discussion toward the realization that without a plentiful source of fresh water, we cannot live. Point out that people have been known to survive for many weeks without food. In those circumstances, however, they had water. Without water, body functions deteriorate rapidly; death can come in days, especially in a hot climate.
3. Tell the students that undoubtedly early people sought places that had a source of fresh water, principally sites near rivers and lakes. But point out that, depending upon geographic location and seasonal variation, rivers and lakes can become dry for long periods. Mention that recent archeological "digs" have revealed fascinating ways that early societies assured long-term water supplies.
4. In some desert societies, scarce rainfall was captured and stored in below-ground, stone-lined cisterns. In other places, where sources fluctuated, water was stored in enormous earthen jugs. Throughout Europe and North Africa, Roman aqueducts still stand as some of the most dramatic early engineering examples found on earth. These arched carriers conveyed water from mountain lakes, rivers, and streams to distant cities at lower elevations. Full advantage was taken of gravity to assure a continued, year-round flow.
5. Mention the fact that many underdeveloped countries, especially those in arid regions, lack the water to develop agriculture. To obtain water it may become necessary to divert rivers, tap into existing sources and carry the water hundreds of miles, or discover subsurface sources and pump it to ground level. A principal area of modern research is removal of salt from sea water. No such processes have yet been found to be economically feasible. Nevertheless, work continues in this fascinating field.
6. It may not be clear to the students why sea water has little value to land-dwelling humans. It may be worthwhile to explain that sea water cannot be used for agriculture because its chemical content counters cell growth in the plants and grains that we eat.

We cannot drink sea water because its high mineral content requires additional water to dissolve and carry away the salts. This is why a shipwrecked sailor avoids drinking sea water.

7. Tell the students that with the discovery of electricity and development of electrical power, a new era began in the water systems. Until then, if a surface water source was unavailable, it was necessary to dig a well and tap into an underground supply. This was extremely arduous work, and frequently endless numbers of "dry wells" were sunk. Even with a well, however, it was necessary to have a source of power for bringing water to the surface (human or draft animal power). After the industrial revolution, this was done by steam and internal combustion engines. Today, electrical power is used to pump and transport water.
8. Conclude the introduction by telling the students that one of the most ambitious water system developments ever undertaken by man was recently completed in California. Owing to the geography of the state, there is abundant rain and snowfall in the northern part but a shortage in the semiarid southern part. The problem was how to make use of the northern water, which ran into the sea. A project of some ten years' duration produced a system of aqueducts, pumping stations, and reservoirs unequaled in the world. The engineering problems of raising the water to great heights to cross mountains were formidable.
9. Tell the students that they will be cast as hydraulic (water system) engineers. Assign the students to work either individually or in pairs.
10. Hand out the student activity sheets to each student (or pair), and review the instructions and figure with the class. Point out that, if they wish, they may draw an original diagram; they need not use the one supplied.
11. Explain the terminology used in the diagram, and point out that the system can be portrayed graphically in many other ways.

Tell the students that the flowchart symbols have the following meanings:



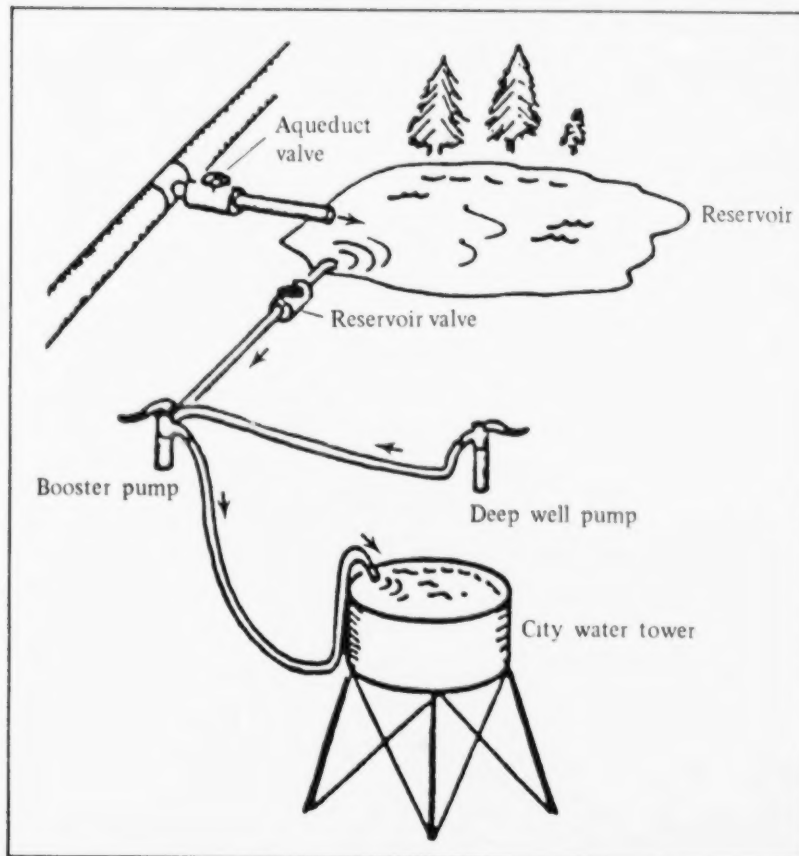
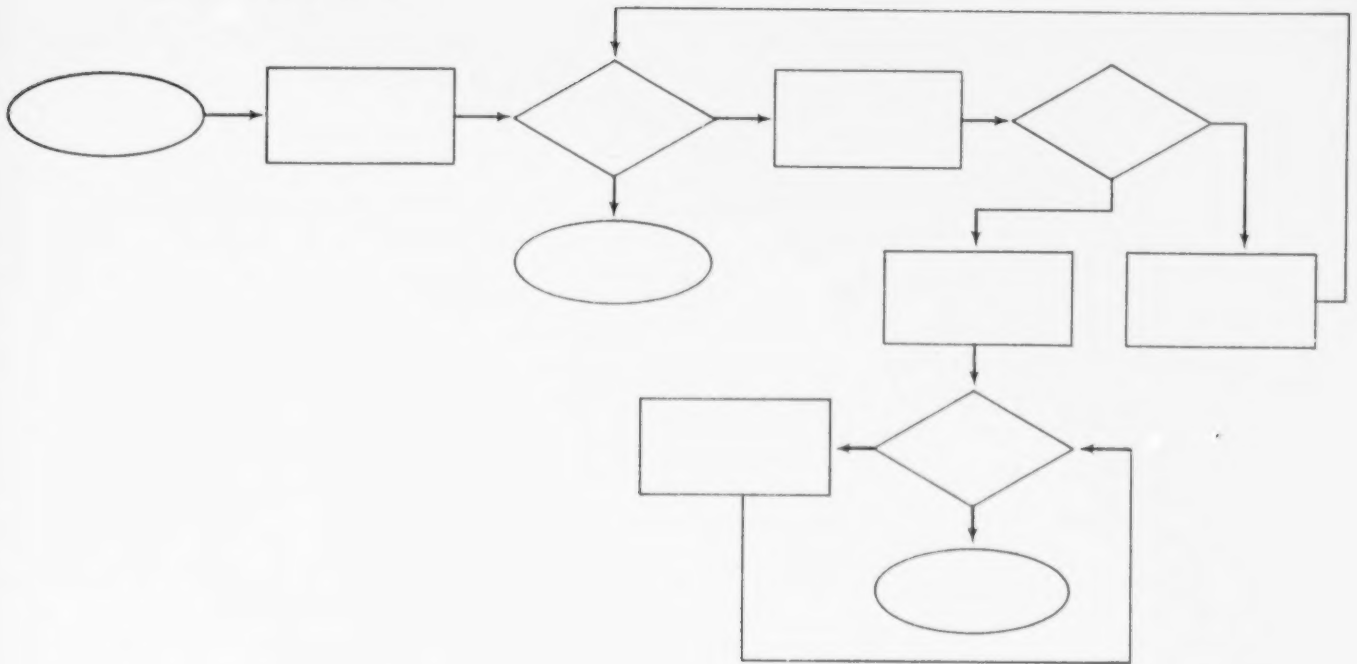
12. Circulate among the students and offer assistance to individuals and small groups as required.
13. When most of the students have finished, invite volunteers to explain their diagrams to the class. Encourage discussion of novel approaches to physical layout or logical connection of elements.
14. Review the correct version, and ask whether anyone has drawn a similar one. Find similarities and differences, and invite the students to select the drawing that is easiest to understand.
15. End the activity by quickly reviewing the skills that were employed, and assure the students that they are the same as those used by engineers in analyzing complex systems.
16. Collect the student materials.

Understanding Flowcharts

Procedure

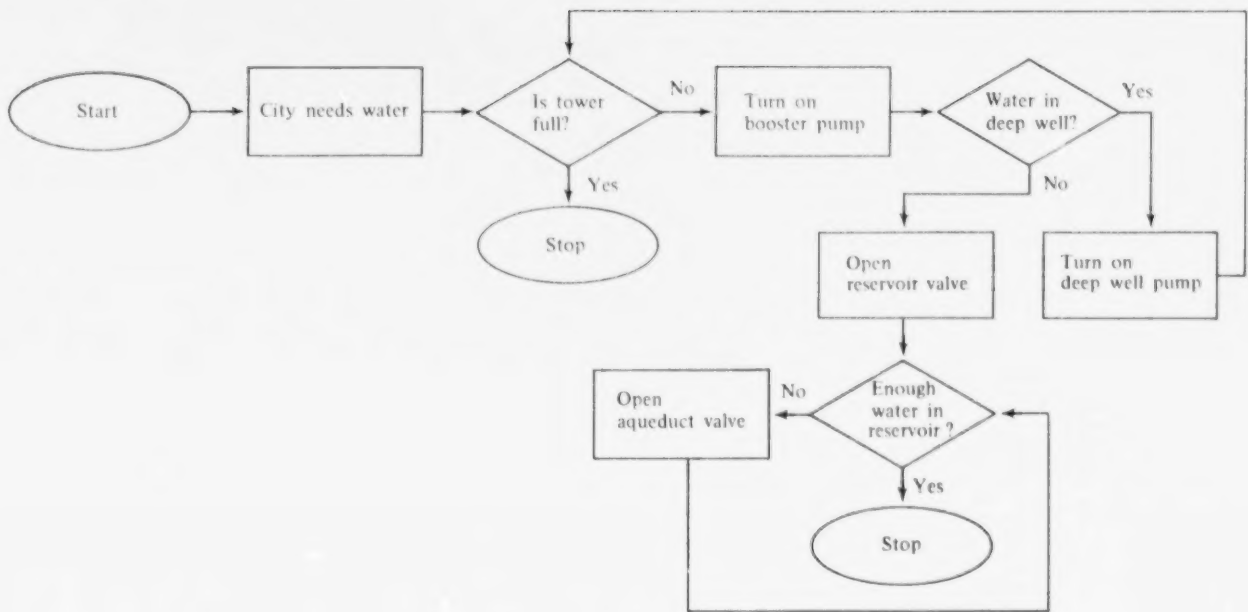
1. You are a hydraulic engineer. Your specialty is water systems, including city water supplies.
2. You have been asked to look into a problem of a community that sometimes has water shortages. Before you become deeply involved in the work, you must prepare a flow diagram that shows the present system.
3. The city manager has provided a description of the present system. Obviously, your city has a continuing need for water. The water is stored in the city water tower. When the water level in the tower is low, the booster pump is turned on. If there is water in the deep underground well, the deep well pump is turned on. If there is not enough water in the deep well, the reservoir valve is opened. If there is not enough water in the reservoir, the aqueduct valve is opened, and the reservoir is filled. Currently, there are no drawings that show how the system operates.
4. The drawing entitled "Water Supply Analysis" shows one way to depict the operation of the water system. There are other ways.
5. Read the description of the city's water system once more, and use the "Water Supply Analysis" figure to fill in the blank flowchart. If you prefer, you may draw a flowchart of your own design.

Water Supply Analysis



Understanding Flowcharts

Water Supply Analysis



(3C) Directing

Construction

Site Safety, an activity supporting the Construction Managerial Processes concept, is designed for approximately 5 class periods.

Resources Needed

None

Objectives

The student will

consider the causes of building and construction accidents;
learn about state and local safety requirements and on-site safety inspections; and
act as a contractor safety referee in deciding the cause of various hypothetical accidents.

Evaluation Focus

☒ Knowledge
☐ Awareness

☐ Problem Solving
☐ Machine/Tool Usage

☒ Attitude

Site Safety

Procedure

1. In this activity, students are cast either individually or in small groups as safety referees for an international building and construction company. Their task is to read accident accounts and take decisive action in accord with printed industry guidelines and the company's own safety rules. The activity starts with a brief account of the importance of industrial safety. Make the point that in addition to obeying licensing and building codes, the contractor must conform to labor codes, industrial safety laws, and other laws that specify how the company may operate. Following this short introduction, lead the class through the working materials. These materials consist of printed instructions, a page of guidelines for the building and construction industry, a page of safety rules for the Global-International Building and Construction Corporation, and eight half-page accident accounts.

If reading achievement and interest levels are high enough, students may work individually. If levels are not high enough, students may be assigned to work in small groups (teams). In either case, the activity proceeds in much the same way.

After reading an accident account, the student makes notations alongside significant statements in the accident accounts to indicate reference to requirements in the guidelines and safety rules. After considering the accident in view of the guidelines and rules, the student writes a short, decisive conclusion. That statement may order someone to be fired, specify that a safety rule be changed, or list some similar action. When everyone has completed the review and made recommendations, students are called on to read them aloud. Assume the role of an impartial judge who, by asking questions, probes more deeply into reasons for the actions. Rival points of view are debated by individuals (or teams), and a consensus is sought on each student's recommendations. The activity ends with a few remarks on the value of applied skills in enabling students to reach their final decisions. These skills include careful reading, perceptive listening, and communicating ideas verbally.

2. Start the activity by asking students to speculate on the most important causes of building and construction accidents. Explain that you are not seeking such reasons as "falling off ladders" or "being struck by falling objects." Rather, you want to know, along general lines, why accidents are not prevented.
3. Lead the discussion to bring out such factors as competency of workers, adequacy of working conditions, degree of hazard, and associated special training, etc. Establish the fact that safety on a building or construction job is a combination of the workman's habits, training, and physical and mental state and the peculiar factors surrounding the job itself.
4. Point out that rather than leave safety to the whim of individuals who may be capricious and inconsiderate of the lives and limbs of others, most state and local governments have defined what must be done to assure safety on the job. These assurances take the form of laws in most places, and conformance is mandatory. If inspectors find

5. Mention that most contractors are more than willing to conform to high safety standards. Ask students to give reasons why it is to the contractor's advantage to uphold high safety standards. Explain that besides causing pain and suffering, accidents cause lost time on the job, impaired efficiency, and lost means of livelihood to contractor and work force alike. Finally, stress the fact that if it can be proven that an accident was caused by the contractor's negligence, insurance companies may refuse to insure the company. This is tantamount to denying the contractor the right to operate.
6. Tell the students that construction and building companies and state industrial safety divisions spend many millions of dollars each year on promoting safety. Point out that the funds are well spent. No one can assign a value to human life. Since human life is priceless, no amount is too much to spend to protect lives on the job.
7. Point out that there is continual research in safety, along diverse lines. Investigations are continually underway to produce superior ways of using tools, handling materials, and carrying out the many operations used in building and construction. In addition to these avenues of exploration, researchers are continually investigating the psychology of safety. By this work, they hope to uncover the factors of human behavior that lead to safe working habits.
8. Conclude this part of the introduction by explaining that the intelligent contractor assigns the highest priority to safety. She or he endeavors to obtain the services of the best safety engineer to be found. And the contractor supports the chief safety officer in all efforts to bring in new safety devices and techniques.
9. Tell the students they will take on the roles of safety referees for a large, international building and construction company. (Choose between having students work individually or in groups of two or three.) If general reading interest is not high or if students will experience difficulty with the materials, it may be advisable to use grouping. That arrangement offers more chance for social interaction.
10. Hand out and review the contents of the student instructions, the Guidelines for the Building and Construction Industry, and the Safety Rules of Global-International Building and Construction Corporation. Tell the students their job will be to review accident reports and analyze them in relation to the rules and guidelines.
11. Tell students that the first thing to search for is the guideline number or rule number that applies to statements in the accident report. When the student finds a "matching" number, she or he copies it alongside the accident report. After looking up all the applicable statements, the student should be ready to draw conclusions.
12. Tell the students that they should decide what should be done in each case. Stress the fact that they are not there to punish. Instead, they are to take decisive action that will prevent recurrence of similar accidents.
13. The manner of distributing accident sheets depends on how you have chosen to group the students. If the students are working individually and you believe all (or almost all) of the students can complete all reports in the allotted time, then each student will

require a complete set. If the students are grouped, fewer copies will be required; one set of accident pages should suffice for each group. Consider the advisability of cutting the pages in half and handing out one numbered accident at a time. To distribute the entire packet of pages at once may discourage slow readers.

14. Encourage the students to read aloud to each other. If the guidelines and safety rules are too long for some students, consider cutting those pages in two and having students work with only half the page. Circulate among the students and help individuals and small groups get started.
15. Preferably, go through the first accident together, pointing out the correct method of annotating statements and arriving at conclusions. Call on a few students (groups) to report conclusions. Ask questions aimed at bringing forth substantiation, even if it is based on value judgements. Phrase a summary conclusion and offer it to the class to vote upon. If it is impossible to gain a consensus, set the ruling aside as undecided.
16. As the students finish a numbered accident, tell them they may summarize their findings in any way they wish. But tell them to be sure they can understand their notes; later they may be called on to read from them.
17. When a student (group) completes a numbered accident, go on to the next numbered one. When the whole class has finished an accident, engage in the sampling and follow up with questions.
18. Toward the end of the class period, gain the attention of the class and ask whether, in the light of having gained further experience in making decisions, anyone wishes to reconsider a previous accident case. Conceivably, arguments and recommendations put forth on one accident may have bearing on another. Encourage the students to question each other's viewpoints. If it is difficult or impossible to obtain a consensus, ask the students to suggest ways of reconciling divergent points of view.
19. Spend a few moments "debriefing" the class on what they have done. Quickly review the skills that they have employed. Ask the students whether they would wish to leave the safety of human lives in the hands of someone who cannot read well. Assure the students that they employed the types of skills that are used routinely by safety personnel in the building and construction industry.
20. Collect the student material.

Site Safety*Procedure*

1. You are a safety referee for the Global-International Building and Construction Corporation.
2. Your job is to make sure that company and other safety rules are followed.
3. Safety matters not decided at the job location are brought to the safety referees.
4. You have several remedies for people who do not follow the company's safety rules, as indicated after you review all information on the case.
5. After your review, decide what to do. You can take the following actions:
 - fire the person
 - give a warning
 - change the company's safety regulations
 - write new safety regulations
 - suggest further action
6. Read both the Guidelines for the Building and Construction Industry and the Safety Rules of Global-International Building and Construction Corporation.
7. This activity contains eight accident reports. As you read the reports, write any guideline number or safety rule number that applies next to important statements.

Examples:

"The safety supervisor admitted that he had never posted any safety bulletins." *You would write "6e—Guidelines" alongside that statement.*

"The employee knew there was explosive gas in the room, but he turned on the light anyway." *You would write "2, 8—Safety Rules" alongside that statement.*

8. Review accident reports and make decisions on them.
9. After reading and annotating each accident account, summarize conclusions in brief notes or written statements.
10. Be prepared to make a verbal report of your conclusions on each accident, referring to handwritten notes or written statements.

Guidelines for the Building and Construction Industry

1. Every contractor must follow these guidelines and do everything possible to make jobs safe.
2. Employees who ignore safety regulations, thereby endangering themselves and fellow employees, *must* be fired.
3. Every construction operation must be planned in advance. When the plans are made, the contractor will design safety into the plans.
4. The contractor is responsible for the following safety factors dealing with *things*:
 - safe work areas and equipment
 - safe roads and vehicles (trucks, tractors, etc.)
 - safe electrical power lines
 - safe handling equipment (elevators, cranes, hoists, etc.)
 - safe tools
5. The contractor is responsible for the following safety factors dealing with *people*:
 - fitting the person to the job
 - giving good safety training and supervision
 - having enough people on hand to do a job safely
 - having a safety program
6. Every contractor safety program must have these features:
 - one qualified person in charge of safety
 - safety bulletins, record charts, and posters
 - investigation and reporting of all accidents
 - regular safety instruction for all employees at least once a month
 - publish rules enforced by the person in charge of safety
7. All contractors will follow state and local industrial safety regulations. Contractors will also cooperate with state and local officials in carrying out the law.

**Safety Rules of Global-International Building
and Construction Corporation**

Rule No.

1. All employees must do everything in their power to make jobs safe.
2. It is the employee's responsibility to report unsafe conditions or operations to the nearest supervisor immediately.
3. It is the supervisor's responsibility to report unsafe conditions or operations to the safety supervisor immediately.
4. The supervisor must insist that every employee follow safety rules. The supervisor will take whatever action is necessary to make the employee observe safety regulations.
5. All employees, including supervisors, must attend the monthly accident prevention meeting.
6. An employee will not be allowed on the job if his alertness is slowed down because of tiredness, illness, medicine, or other causes.
7. Any injuries must be reported to the supervisor immediately so that medical treatment or first aid can be given as soon as possible.
8. It is the employee's responsibility to take reasonably safe care of any condition or operation that could be unsafe.
9. No employee can be asked to work in a job that is known to be unsafe.
10. Where safety may be endangered, employees will not "fool around" or engage in horseplay.

Accident Report 1

The Global-International Building and Construction Corporation (Global-International) is building an airport in northern Alaska. The safety supervisor was hired about six months ago. He is well liked by all the employees. He gets along well with everyone. His monthly safety meetings are well attended. He tells funny stories at the meetings and shows comical films about accidents. Last month there was a tragic accident. It was 30 degrees below zero. A worker went to a storage shed to get heating oil for the cabin. Shortly thereafter, there was a violent explosion and fire. Three workers lost their lives. It was found that unmarked cans of gasoline were stored next to the marked cans of heating oil. A careful review was made of the safety supervisor's past record. It was found that he had been fired from two jobs. He lied about this on his employment application. One time he was fired because he allowed paint remover to be stored in the same room as canned food and drinking water. Another time he was fired because he failed to store aviation fuel in approved drums in an approved storage area.

Accident Report 2

Global-International is building a mountain road in a South American country. Most of the work is done in the dry season because when the rainy season comes, very little work can be done. Work was progressing all right during the summer. As the rainy season approached, the superintendent rushed to get the final stretch of road completed. Local officials warned the superintendent about the coming rains, and she agreed that work would have to stop when the first rains came. One morning a worker arrived on the job early and noticed that the ground was very loose where trucks would soon be arriving, but he said nothing to his supervisor. When the trucks arrived, they had trouble getting through the loose earth. There was a sudden rainfall, and the earth turned to mud. The truck drivers hadn't driven in these conditions before, and they did not know what to do. Several tried to get through, but their trucks overturned and slid down the mountainside. Three drivers were seriously injured. The safety supervisor cannot explain why the accident happened.

Accident Report 3

A large load of steel was delivered to the Global-International construction area on the East Coast, where a chemical plant was being built. There had been a severe thunderstorm the previous night, so the receiving yard workers had worked in the rain all night, and they were exhausted. When the steel trucks arrived, the drivers were anxious to unload and go on as quickly as possible. They had been driving in the storm all night. They, too, were exhausted and anxious to get some rest. The supervisor of the receiving yard did not have enough workers to do the job properly, so he asked several receiving yard drivers to help out. They answered his request for help. Unfortunately they were not experienced in actually handling heavy steel. As a large I-beam was being unloaded from a truck, one of the receiving yard drivers failed to understand the signals of a winch operator, and she stepped too close to the moving beam. The winch operator pressed an emergency switch, but the strain was too great for the winch. Its steel cable snapped and lashed out like a giant whip. Two workers were knocked to the ground with serious injuries. A third one was badly cut by the frayed ends of the wire cable. The yard supervisor told the safety supervisor that he had not ordered

the workers to help but had asked for volunteers. For this reason, he does not feel he is at fault.

Accident Report 4

In the southeastern part of Tennessee, Global-International is constructing a dam. Until recently, except for a few minor accidents, the safety record had been excellent. The safety supervisor is known as a tough but very qualified person. After a period of heavy wind, several workers reported small cracks in the lower part of the concrete work. Their crew chief inspected the cracks and told the workers that the wall was possibly unsafe. He told them to stay away from that section of the wall until further notice. The next day, he had a crew jackhammer out the cracks. He wished to inspect the inside to see how far the cracks went into the concrete. As the workers were using jackhammers, a large portion of the concrete broke loose and fell on them. All are in the hospital with injuries. The safety supervisor stated that the work was done without her knowledge, but the crew chief claims he took reasonable safety measures. He points, for example, to the fact that he ordered regular work crews away from the area.

Accident Report 5

This accident could be called a "one-in-a-million" chance. It occurred in a heavily forested area of Idaho. Global-International is building a narrow road into a national park area. The company uses helicopters to carry engineers and surveyors into the forest area. The helicopters are based in a cleared area. Approval to operate the helicopters was obtained from the federal and state governments. The small base is staffed by three employees, who live in temporary quarters. Their main job is to keep in touch with the helicopters, furnish weather information to the helicopter pilots and work crews, and so on. Late in the summer, one of the workers at the base became ill. He discussed his condition with a doctor over the radio-telephone, and she prescribed medicine, which was flown into the base. The man took the medicine according to the doctor's instructions. He awoke feeling dizzy and very tired from the medicine. Later in the morning, while his two companions were clearing out brush, he was monitoring the radio when a call came in from one of the helicopters. The pilot was lost and needed bearing information. The man gave information to the pilot, but radio contact was lost. Later, to his horror, the ill man discovered that he had given the wrong information. The helicopter has been lost for several months, and the two occupants are feared dead. When representatives of Global-International's safety department visited the helicopter base to make an investigation, they found that there was no safety program, as such. The workers at the base claimed in an operation as small as theirs, safety depended on what each one thought was reasonable. The worker responsible for loss of the helicopter recovered his health but later resigned the job.

Accident Report 6

This serious accident took place in the Midwest, where Global-International was building a steel mill. The framework of the building was up. Outside panels and windows were being attached. Workers were standing on two-story high scaffolds. Suddenly, a scaffold collapsed,

dropping a dozen workers almost 20 feet to the ground below. All were seriously injured. It was found that the scaffold had been incorrectly assembled that morning. The workers responsible said they had told their crew chief they had worked only with wooden scaffolds before and had never worked with steel scaffolds. The chief admitted that he told the men to go ahead anyway because he thought they could do the job correctly. They worked unsupervised on putting up the scaffolds.

Accident Report 7

Global-International is under contract to rebuild a structure of the General Pickle and Potato Chip Company of Los Angeles. The accident that occurred there recently could have been fatal. But, fortunately, fast action by the local police prevented a tragedy. The end result, happily, is amusing. Three workers were being lowered into a 10,000 gallon (empty) steel tank used for curing pickles. The first person down tugged on the line twice, signaling that she wanted to be raised. The workers at the top thought she had tugged only once, indicating all was well. They proceeded to lower two other workers into the tank. They then left the top of the tank to have a morning coffee break. When they returned, they heard faint tapping on the tank. Not knowing what the signals meant, they quickly raised the three workers. Two were unconscious, and one was almost unconscious. The workers administered mouth-to-mouth breathing and called the police emergency unit. Within minutes, all three were receiving oxygen. Apparently, acetic acid (vinegar) fumes overpowered them. The fumes had collected in a "pocket" at the bottom of the tank. The victims have recovered completely, and their only difficulty was that other workers refused to come near them for a week, owing to the smell of vinegar that they carried. The safety inspector claims that he carried out his responsibility by telling the work crews to use a system of signals in case of danger.

Accident Report 8

In the Pacific Southwest, Global-International is installing an oil pipeline. The main work is digging a trench for the underground, large-diameter pipe. Soil engineers have worked on a three-shift basis to sample soil along the way. This is necessary so that workers will know how much support to place along the trench walls to prevent cave-ins. At one point, the soil engineers found a type of soil that first appears hard, but, when it becomes exposed to the air, becomes soft and dangerously "runny." The soil engineers informed the safety supervisor of this. The safety supervisor wrote a special bulletin on the unsafe type of soil. The bulletin was posted in nine places in the work camp. A few days later, a crew was working along a deep trench when, without warning, the sides caved in. Several workers were rescued immediately, but three were not found until the next morning, suffocated beneath the soft soil. When questioned, the crew chief and workers claimed they had not been told about the type of soil that turns soft on exposure to air.